7.0 RECYCLED WATER SUPPLY CHARACTERISTICS AND FACILITIES

7.1 PURPOSE

The purpose of this chapter is to identify the available recycled water supply and the associated storage capacity needs required to meet the projected water demands identified in **Chapter 6.0**. This chapter also provides discussion of recycled water delivery, WWTRF operations, and provides effluent management strategy recommendations.

This chapter is divided into the following sections:

- Recycled Water Supply Needs
- Recycled Water Supply Sources
- WWTRF Effluent Management
- Recycled Water Storage and Delivery
- Supply and Storage Recommendations

7.2 RECYCLED WATER SUPPLY NEEDS

The recycled water supply required to meet existing user demands is approximately 2.7 MGD for ADD and 6.8 MGD for MMD, including agricultural users. This results in approximately 3,065 acre-feet (AF) of recycled water required annually to meet demands under existing conditions. (Existing supply needed to support demands within the City are 0.2 MGD for AAD and 0.5 MGD for MMD).

The future reclamation system has been planned to supply potential demands that exist at an elevation of approximately 160 feet above sea level or less and are generally bounded by Lincoln Boulevard to the east, and the City's SOI boundary to the west. The recycled water distribution system has been planned to supply demands within the City (west of Lincoln Boulevard), SUD-A, Village 4, Village 5/ SUD-B, Village 6, and Village 7. This excludes the demands of potential users within the City located east of Lincoln Boulevard, and those within Village 1, Village 2, and Village 3. The future recycled water supply rate needed at buildout of the recycled water service area is estimated as 2.6 MGD for ADD and 6.5 MGD for MMD. Future supply needs include the potential future demands that were identified in **Chapter 6.0**. This results in approximately 2,900 AF of recycled water needed annually at buildout.

7.3 RECYCLED WATER SUPPLY SOURCES

Final effluent from the City's WWTRF is used to supply the reclamation system. The WWTRF is considered a regional wastewater treatment and reclamation facility, treating wastewater collected from within Lincoln's city limits and Placer County's SMD1 service area. The WWTRF is expected to provide service to future development within the City's SOI and accept additional wastewater flow from other regional entities, including the City of Auburn and Placer County's Bickford Ranch development. The existing agreement (COJA) between the City of Lincoln and Placer County entitles the County to claim a portion of the effluent produced at the WWTRF, but the County has yet to do so. Also described within the agreement is the City of Lincoln's right to receive a portion of WWTRF effluent flow proportional to its wastewater contribution. For purposes of this Master Plan, it has been assumed that the City can only rely on recycled water supplies derived from the wastewater collected from within the City's General Plan area. Additional details of this agreement between the City of Lincoln and Placer County have been described in **Section 3.4**.

Historically, the incoming ADWF at the WWTRF has been increasing and it is projected to continue to increase in the future[6] with development of the City's SOI. Estimates of future wastewater flows from undeveloped areas within the City's General Plan area are presented in the City's Wastewater Collection System Master Plan (Stantec, 2018). A wastewater generation rate of 250 gpd/EDU based on the City's Design Standards, is used to estimate base flow from undeveloped areas. This wastewater generation rate is much higher than what has been historically observed at the WWTRF. The rate is meant to provide a conservative estimate of flow in the collection system and provide a factor of safety in collection system design to account for added flow associated with rainfall dependent inflow and infiltration (RDII). Since 2005, the highest annual average wastewater generation rate observed at the WWTRF was approximately 175 gpd/EDU.

Drought conditions persisted in Lincoln, and much of California between 2011 and 2016. During this time the City's average wastewater generation rate fell to approximately 155 gpd/EDU. This wastewater generation rate has been used to scale the estimates (155 gpd/250 gpd) presented in the Collection System Master Plan and provide a conservative projection of future recycled water supplies that could become available with future development. The wastewater flow projections from the Collection System Master Plan and the scaled reclamation planning projections are presented in **Table 7-1**. Only estimates of future wastewater flow from City planning areas[7] have been scaled to reflect lower generation rates. Regional wastewater flow estimates reflect those outlined in existing agreements and are used directly.

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[6] A flow reduction was observed through the 2011 to 2016 drought, but the upward trend has returned for 2017 and 2018.

[7] Estimates exclude regional entity flow projections

Table 7-1 Wastewater Collection System ADWF and Scaled Reclamation Supply Projections

Contributing Area	ADWF Estimate – Collection System Planning (MGD)	ADWF Estimate – Reclamation Planning (MGD)
Lincoln – Current ADWF (1)	2.8	2.8
SMD1 Flow – Current ADWF (1)	1.2	1.2
Future Additional SMD1 Flow (2)	3.0	3.0
Infill within city limits	3.0	1.8
Village 1	1.4	0.9
Village 2	1.2	0.7
Village 3	1.3	0.8
Village 4	1.4	0.9
Village 5/SUD-B	3.9	2.4
Village 6	1.3	0.8
Village 7	0.9	0.5
SUD-A	2.6	1.6
SUD-C	1.6	1.0
Additional Spaces	1.0	0.6
Bickford Ranch Development (2)	0.4	0.4
City of Auburn (2)	2.5	2.5
Lincoln Total	**22.3**	**14.9**
WWTRF Total	**29.4**	**22.0**

1. Estimate reflects existing dry weather flow conditions and is not scaled for use in reclamation planning.
2. Regional flow estimate outlined in the City's COJA and is not scaled for use in reclamation planning.

7.4 WWTRF EFFLUENT MANAGEMENT

The current WWTRF effluent management strategy is to discharge what is permissible to Auburn Ravine without effluent cooling facilities, to directly reuse the effluent for reclamation demands, and to store any remaining balance in the TSBs at the WWTRF. The WWTRF onsite TSBs provide seasonal storage of tertiary treated and disinfected wastewater until disposal is feasible or recycled water demand exists. The required volume of the TSBs is determined by the extent that effluent flows exceed allowable creek discharges throughout the fall, winter, and spring. In practice, the primary period of creek discharge occurs in winter months and main period of reclamation occurs in the summer months. A water balance is used to estimate and track all inflow and outflow from the system to determine the tertiary storage and land disposal capacities required. The water balance and overall effluent management strategy is highly dependent on receiving water limitations outlined by the WDR Order.

7.4.1 Ongoing Effluent Management Impacts

Time-Schedule Order – Auburn Ravine Creek Temperature Study

The most recently adopted WDR Order (R5-2018-0081) imposed more stringent temperature receiving water limitations. The revised temperature limitations will require the WWTRF to store more water that could have otherwise been discharged to the creek. The City indicated to the Regional Board that there may be insufficient storage capacity at the WWTRF to comply with the revised limitations. On January 14th, 2019 the City submitted a request for a compliance schedule supporting the infeasibility of complying with the revised limitations (Order R5-2019-1003).

The old permit (Order R5-2008-0156) used to read:

> **Temperature**. The temperature shall not be made to increase more than 5 °F compared to the ambient stream temperature.

The new permit (Order R5-2018-0081) includes the following additional temperature limitations:

> **Temperature**. The annual average temperature to increase more than 5 °F compared to the ambient stream temperature ***<u>and</u> shall not cause the receiving stream temperature to rise above:***
>
> ***a. 58 °F on a monthly average and weekly median basis from 1 October through 31 May.***
> ***b. 64 °F at any time from 1 October through 31 May.***
> ***c. 5 °F over the ambient background temperature as a daily average for the period from 1 June through 30 September.***

The City requested the interim use of a nearby Regional Stormwater Basin (RSB) as additional storage capacity, as well as time to study options including determining if the receiving water temperature limits are appropriate or need to be revised. Depending on the outcome of the Auburn Ravine Creek temperature study, the City may require additional storage beyond the total tertiary storage capacity, of approximately 330 MG or other facility upgrades, which would require additional time to plan, design, finance, and construct in order to comply with the receiving water limitations.

The time-schedule order R5-2019-1003 describes the steps that the City will take in order to correct potential violations of the receiving water limitations for temperature. The time-schedule order provides regulatory coverage for an interim solution to wastewater storage and disposal issues while a long-term solution is being developed. The revised receiving water limits were developed without conducting a site-specific study, so they are based on conservative assumptions. Before moving forward with costly upgrades to increase storage, the City plans to conduct a site-specific temperature study in consultation with state and federal fishery agencies to determine the appropriate temperature receiving water limitations for protection of salmon and steelhead migration and spawning.

If upon completion of the site-specific study on Auburn Ravine Creek, additional storage capacity or other facility upgrades are needed to meet the receiving water limits, the City plans to evaluate compliance options which include but are not limited to:

A. Building more tertiary storage facilities,
B. Increasing reclaimed water use; and/or
C. Building effluent cooling features.

The following time schedule and reporting provisions are outlined in time-schedule order (Order R5-2019-1003):

1. Ensure completion of the compliance project by submitting the following technical reports according to the time schedule outline below:

Task	Compliance Date
Submit Site Specific Temperature Study Work Plan The Work Plan shall be developed through consultation with the DFW and National Marine Fisheries Service staff to evaluate the appropriate temperature receiving water limitations for protection of salmon and steelhead migration/spawning in Auburn Ravine.	**1 June 2020**
Submit Final Temperature Study	**1 January 2022**
Submit Treatment Feasibility Study Work Plan and Schedule (If Necessary). Work plan and schedule shall consider alternatives to provide long-term compliance with temperature receiving water limitations.	**1 April 2022**

2. Discharger shall comply with the following interim receiving water limitation through 1 April 2023, or when the Discharger is able to come into compliance with the receiving water temperature limitations in Order R5-2018-0081.

   Receiving Water Limitations for Temperature. The discharge shall not cause the natural temperature in Auburn Ravine Creek to be increased by more than 5°F as a daily average between 1 October and 31 May. The site-specific receiving water limitations in Order R5-2018-0081 shall apply between 1 June and 30 September.

3. For the term of this Order, the Discharger shall manage the discharge of tertiary treated wastewater from the Facility to the Regional Stormwater Basin (RSB) in accordance with the Standard Operating Procedures (SOPs) and the following prohibitions and specifications:

a. The two existing TSBs, and planned third TSB, shall be used to the maximum extent possible before tertiary treated wastewater is end to the RSB for storage.

b. If tertiary treated wastewater is discharged to the RSB, all water (i.e., wastewater/storm water mixture) must be removed from the RSB prior to utilizing the RSB as a storm water retention basin.

c. The discharge of tertiary treated wastewater to surface waters other than authorized in Order R5-2018-0081 (NPDES Permit No. CA0084476), is prohibited.

d. When in use for storage of tertiary treated wastewater, the RSB shall be operated per the Operating Requirements as follows:

   i. Public contact with wastewater shall be precluded through such means as fences, signs, and other acceptable alternatives.

   ii. The RSB shall be managed to prevent breeding of mosquitos.

   iii. The discharge of wastes classified as "hazardous" or "designated" as to the Facility ponds, is prohibited.

   iv. Objectionable odors originating at the RSB shall not be perceivable beyond the limits of the wastewater treatment and disposal areas (property owned by the Discharger).

   v. A minimum of 2-feet of freeboard is required when storing tertiary effluent in the RSB. Freeboard shall be measured at the spillway thus the water level shall not be allowed to exceed 106.0-foot elevation, resulting in a reduced capacity of approximately 70 MG.

Loss of Effluent Disposal Area

The WWTRF currently leases an irrigation area owned by Placer County for purposes of effluent disposal. The site is approximately 192 acres of irrigatable area. It has been identified that the County intends to repurpose the area and will end its lease with the City within the next five years. The WWTRF currently utilizes approximately 942 acres of land as effluent disposal area (including the County Site). These areas include the Machado Farm, On-site Areas (Warm Springs), County Lease Site, and uses within the City (Sierra Pacific Industries, city parks, landscaping, etc.). City uses are not considered in the water balance calculations, due to inconsistent demand and on-going implementation. After the loss of the County Lease Site, the total land disposal area will be reduced to approximately 750 acres.

WWTRF Expansion Project

The City of Lincoln is currently in the process of expanding the capacity of its WWTRF. The WWTRF is currently permitted for an ADWF of 5.9 MGD, upon completion of the Phase I improvements the ADWF will increase to 7.1 MGD, and with the completion of Phase II the ADWF will increase to 8.0 MGD. The expansion project will be implemented in two phases.

- Phase I – The first phase of the expansion project will increase the WWTRF treatment capacity by 1.2 MGD with the addition of an additional oxidation ditch and related components. The project will also expand the reclaimed water storage capacity by 142 MG with the construction of an additional effluent storage basin.
- Phase II – The second phase of the expansion project will further expand the facility's treatment capacity by 0.9 MGD with the construction of an additional clarifier and related components.

The WWTRF currently has 190 MG of tertiary storage capacity. After Phase I is completed, the tertiary storage capacity will be increased to 332 MG. Discussion of either purchase or seasonal lease of a 70 MG stormwater basin located adjacent to the tertiary storage basins has been made to further expand storage capacity if required.

7.4.2 Recycled Water Delivery & WWTRF Operations

Figure 7-1 depicts the existing seasonal effluent management strategy. Monthly totals are presented for approximate wastewater influent volume, presented as the total of stacked bars by wastewater source. Overlaying the stacked bar chart are line graphs depicting the potential reclamation demand of existing use areas (maximum irrigation potential of existing agricultural users and on-site reclamation areas) and actual 2017 reclamation flow supplied is also shown. Wastewater sources reflect ADWF data collected at the WWTRF in July, August, and September of 2017. Estimates of monthly inflow and infiltration (I/I) volumes were calculated based on the annual influent flow pattern observed at the WWTRF from 2014 to 2017.

Currently the operation of the TSBs allows storage of significant amounts of effluent that could have otherwise been discharged to Auburn Ravine, with the objective of conservatively meeting receiving water limitations and maximizing the amount of recycled water available in the dry season. This is management strategy is currently possible because the plant operates at less than its existing ADWF capacity and the current TSB volume was designed to provide sufficient capacity at the design ADWF.

The required TSB storage volume is determined through the development of water balance scenarios that simulate various conditions by adjusting water balance inputs. A water balance update and evaluation of the storage volume required to accommodate the WWTRF Expansion Project was completed as part of the project design effort. The evaluation assesses the allowable effluent discharge volume to Auburn Ravine in drought years and in years with 100-yr return frequency precipitation, to determine the corresponding storage volume and land disposal (reclamation) area requirements. The impacts of the updated WWTRF WDR Order that limit effluent disposal, improvements of the WWTRF Expansion Project, and changes to existing effluent land disposal contracts were considered in the water balance update.

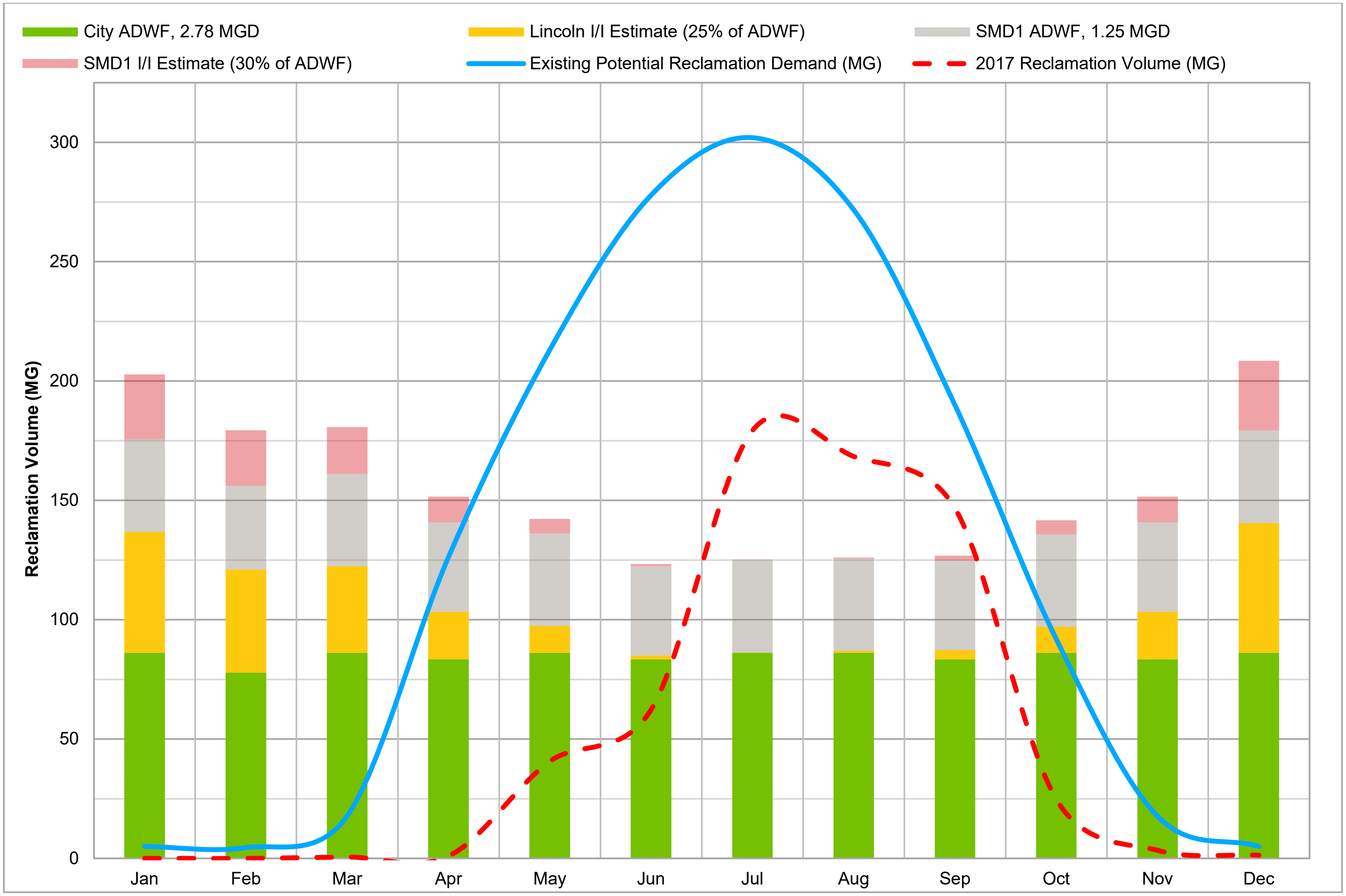

Figure 7-1 Existing Effluent Management

Further discussion of the water balance update and assessment is provided in the following section. The water balance assumes the maximum amount of effluent is discharged to Auburn Ravine and TSBs are emptied as soon as possible. Under this effluent management approach (as assumed in the water balances) the required storage volume is minimized at the expense of potentially leaving a portion of the existing reclamation demand unsatisfied. Having a higher potential reclamation demand than available supply ensures that all the City's effluent can be disposed of under the given conditions. This makes for effective effluent management approach but is in conflict with goals to provide a reliable reclamation supply that consistently meets demands, creating an operational challenge to meet both objectives.

Figure 7-2 includes reclamation demands supplied in 2017, the estimated potential demand (based on the City's current on-site reuse areas and agricultural use areas), and the estimate of future reclamation demands under future conditions. The total annual buildout reclamation demand estimate equates to 950 Mgal or 2,900 AF (presented in **Section 6.6**), which is less than the existing demands of the City's existing agricultural users and on-site reclamation areas (1,000 Mgal or 3,070 AF). The buildout reclamation demand estimate falls within the available reclamation supply of the limiting water balances. As large agricultural demands are phased out, they will be replaced by those of future users within the recycled water service area.

If the City wishes to supply the existing potential demands and those of future users under interim conditions, additional seasonal storage may be necessary. The water balance and tertiary storage requirements are further described in the following section. The water balance, storage requirements, and overall WWTRF effluent management strategy will be reassessed after the completion of the Auburn Ravine temperature study and should be continuously reconsidered as objectives change over time.

Figure 7-3 presents an estimate of the monthly effluent volume under buildout development conditions. The current estimate of future reclamation demands is projected to make up only a small portion of the total effluent volume produced at the WWTRF. Because the projected amount of effluent produced at the WWTRF will increase overtime and the total volume of reclamation demand will roughly remain the same, the City will need to pursue alternative effluent disposal methods and wastewater flow increases from future development.

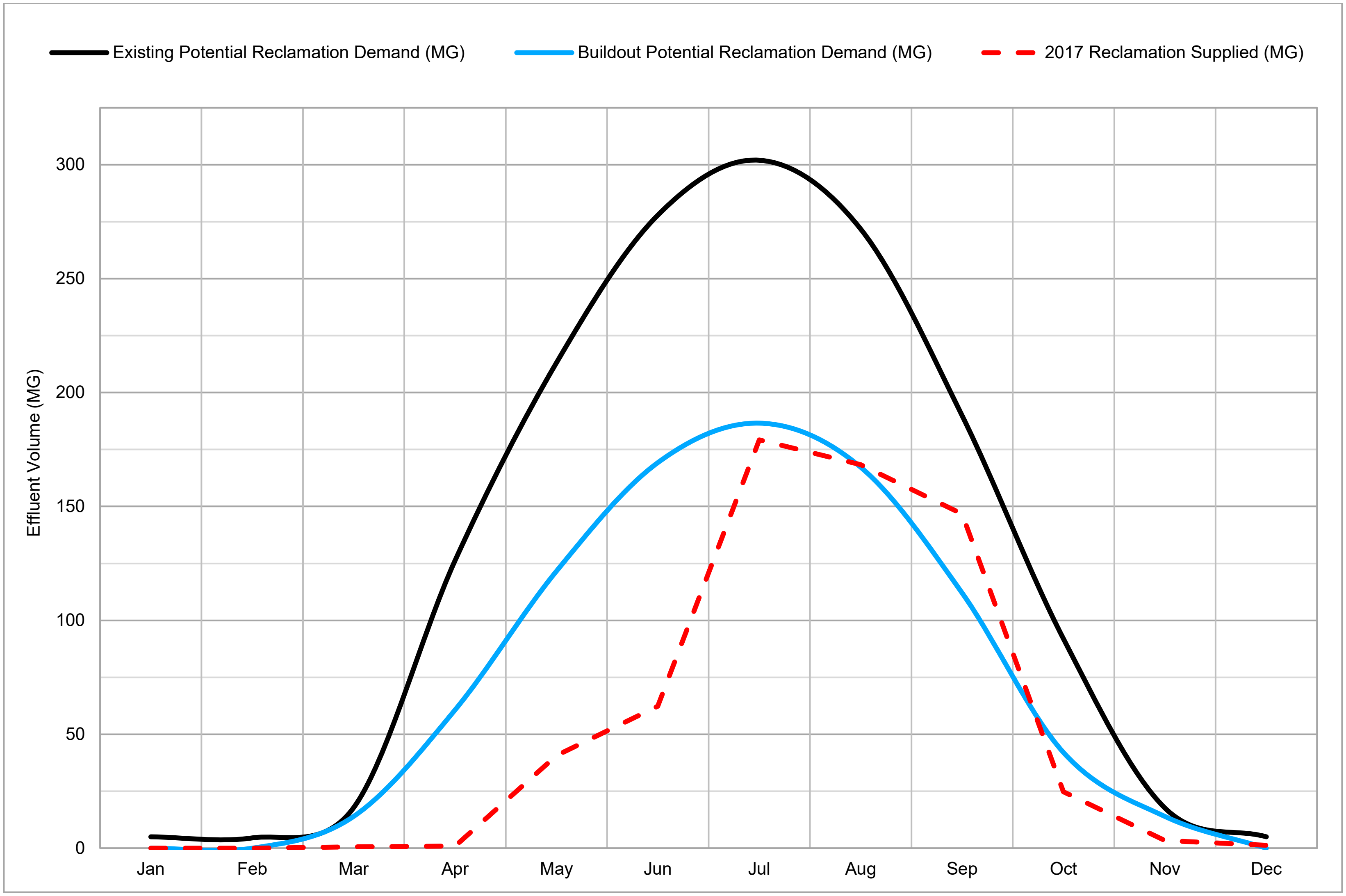

Figure 7-2 Reclamation Demands

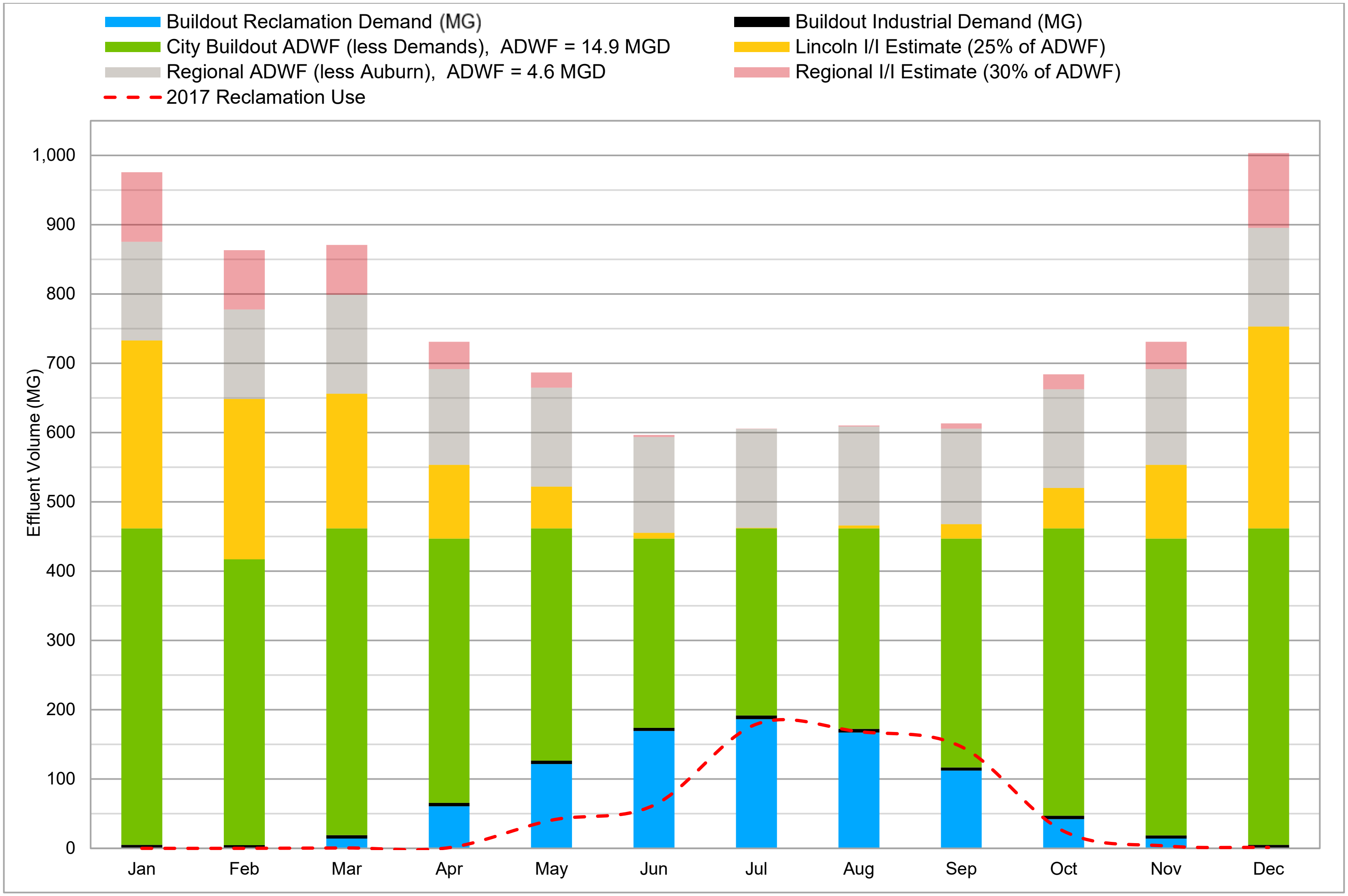

Figure 7-3 Future Effluent Management Need

7.5 RECYCLED WATER STORAGE AND DELIVERY

Two types of storage are required to operate the recycled water distribution system:

- Tertiary Storage
- Peak Hour Storage

Tertiary Storage is storage volume required to store off-season effluent on an annual basis for use during periods of high reclamation demand. High reclamation demand periods are projected based on an agronomic cycle in this Master Plan, which corresponds to summer irrigation. The existing TSBs have been designed to minimize volume and the associated costs while maximizing effluent discharge to Auburn Ravine. In an alternative effluent management approach which maximizes storage and reclamation supply, the storage volume would be calculated based on the ability to maximize reclamation demands as feasible with the available effluent and would theoretically, result in less discharge to Auburn Ravine and a higher storage volume than for the current effluent management approach.

However, to meet the projected peak reclamation demands projected in this Master Plan, the existing storage volume based on effluent management is enough to serve both objectives. This is demonstrated by the fact that the existing 190 MG of storage can supply the existing reclamation demands, which exceed the buildout demands established herein. Therefore, no new reclamation storage is required to fulfil the needs of this Master Plan at buildout.

Peak Hour Storage is needed to buffer demand fluctuations throughout the day. It provides the supply to meet demand under peak hour conditions. Peak hour storage provides reclaimed water to meet the difference between PHD of customers and the effluent supply flow from the WWTRF. The volume required for this storage component is dependent upon the hourly variation of the customer's demand and the diurnal variation in effluent flow from the WWTRF as it is currently operated. Effluent flow from the WWTRF is currently equalized in the facility's maturation ponds. Therefore, effluent diurnal variation is very small and approximately equal to the average daily flow rate entering the plant – in the summer, when most reclamation will occur, this is roughly equal to the ADWF rate. New peak hour storage facilities would likely be in the form of a covered storage pond with floating liner or above ground tank at the WWTRF.

7.5.1 WWTRF Water Balance and Tertiary Storage

To date, the TSB design volume has been minimized based on an effluent management strategy that maximizes discharge and disposal. This approach to design reduces costs associated with additional TSB volume. Water balance calculations are used to determine the required tertiary storage volume and land disposal area under various permutations of influent flow, effluent storage, discharge, and disposal conditions. The most recent WWTRF water balance update assessed the impacts of recent planning and regulatory developments on effluent management at the WWTRF.

The following conditions were simulated in the water balance to determine their impact on tertiary storage and effluent disposal area required:

1. **Increased WWTRF ADWF Capacity –** An increase in the permitted average dry weather flow (ADWF) associated with the WWTRF Expansion Project, and the anticipated wastewater flow into the facility in the near-term.
2. **Increased Tertiary Storage Capacity –** The construction of 142 MG of additional tertiary storage capacity at the WWTRF site as part of the WWTRF Expansion Project and the interim use of the 70 MG RSB.
3. **Creek Discharge Capacity – Increased Discharge Rate and Temperature Constraints:** Adjustments to the regulatory permit defining the WWTRF effluent discharge capacity, increasing the allowable discharge rate to 25 MGD but further restricting receiving water temperature limitations. The existing effluent pump capacity (20.4 MGD) was also considered.
4. **Disposal Area – County Leased Reclamation Area (Pivots):** The future loss of one of its existing effluent disposal areas (County Leased Area), reducing the available land disposal area by approximately 192 acres to 750 acres.

The following scenarios were developed to determine the impacts on effluent management based on the corresponding parameters. Each scenario and its corresponding parameters are shown in **Table 7-2**.

Table 7-2 Water Balance Scenarios and Parameters

Water Balance Scenarios	Influent Flow (MGD)	Storage Volume (MG)	Effluent Discharge Capacity (MGD)	Effluent Disposal Area (Acres)
Scenario 1 - Existing Conditions	5	190	20.4 (1)	942
Scenario 2 - Phase II Expansion Project	8	402	20.4 (1)	942
Scenario 3 - Phase II Expansion Project w/o County Site	8	402	20.4 (1)	750
Scenario 4 - Phase II Expansion Project w/ Higher Discharge	8	402	25.0 (2)	750

(1) Current effluent pump capacity to Auburn Ravine.
(2) Current permit limitation to Auburn Ravine.

The 100-year rainfall condition governs the amount of tertiary storage capacity required and was used in this assessment. The results of the water balance scenarios are summarized below:

Scenario 1 – The WWTRF has sufficient capacity under existing conditions and 176 MG of storage and 800 acres of land disposal area are required.

Scenario 2 – When ADWF increases to 8.0 MGD the WWTRF will need to expand storage capacity by 105 MG and land disposal area 458 acres, requiring 458 MG of total storage and 1,400 acres of land disposal area.

Scenario 3 – When ADWF increases to 8.0 MGD and the County Site can no longer be used, the WWTRF will need to replace the land disposal area lost.

Scenario 4 – Increasing the effluent pump capacity to 25 MGD when ADWF increases to 8.0 MGD and the County Site can no longer be used, would limit the additional storage required to 46 MG and the additional land disposal area to 250 acres. Reducing the total required storage to 453 MG and land disposal area to 1,000 acres.

The results of the water balance analysis indicated that improvements to effluent management, either additional tertiary storage or land disposal area, will be needed under Phase II conditions. The ADWF is projected to exceed 8.0 MGD upon development of Village 1, Village 7, Village5/SUD-B, and infill of existing service areas. Therefore, it assumed that Scenario 4 projects planning conditions on a long-term basis. The required amount of tertiary storage volume is approximated as 453 MG under 8.0 MGD ADWF conditions, respectively, when the maximum discharge to Auburn Ravine is maintained at the permit limit of 25.0 MGD and the revised temperature limitation is also considered. This projected volume also assumes that the City will maintain its land disposal area of approximately 942 acres. The WWTRF will soon have 332 MG of TSB volume, about 120 MG less than the total volume required to increase the ADWF to 8.0 MGD. After considering use of the RSB, which adds an additional 70 MG of storage capacity, 50 MG of storage are still required upon completion of the WWTRF Expansion Project.

It is assumed that the WWTRF will expand pumping capacity of the EPS and maintain or replace the land disposal area currently accounted for by the County Leased site. The TSB capacity will be expanded as part of the WWTRF Expansion project and the RSB will provide additional storage capacity in the interim before ADWF reaches 8.0 MGD. With the use of the RBS, the WWTRF currently has 260 MG of TSB capacity. After the completion of WWTRF Expansion Project, this capacity will be expanded to approximately 402 MG.

This amount of storage volume is considered acceptable under interim conditions because the actual ADWF is currently only half of the Phase II design capacity. The required amount of tertiary storage volume is ultimately dependent on maximizing effluent discharged to Auburn Ravine Creek while meeting the receiving water limits and maintaining permit compliance. Therefore, the amount of additional tertiary storage required will be revisited upon completion of the site-specific study on Auburn Ravine Creek and allow storage to be expanded prior to ADWF reaching 8 MGD.

The follow is recommended based on the results of the water balance update and assessment:

<u>Existing Conditions</u>

1. Retrofit effluent pumps to achieve higher discharge when permissible.
2. Operations should utilize the full five degrees of impact on Auburn Ravine Creek
3. Improve instrumentation to allow more accurate and definitive temperature averaging, to maintain compliance with permit limitations.

4. Utilize the RSB for effluent storage if needed.

5. Continue to expand reclamation wherever feasible.

<u>Long-term (Phase II) Conditions</u>

1. Expand WWTRF storage capacity on or off site.

2. Increased flow from growth in SMD1, Bickford Ranch, and Village 1, as currently planned, will not bring associated reclamation potential, but Village 5 and Village 7 should maximize reclamation.

3. Consider revising the recycled water service area to include currently excluded reclamation areas, including higher elevation areas (Village 1, Village 2, etc.).

4. Complete site-specific Auburn Ravine temperature study to refine the discharge limitations to Auburn Ravine Creek.

5. Complete an extensive and detailed effluent management plan for long-term planning upon permit adoption of final receiving water discharge limitations.

7.5.2 Daily Storage and Delivery

As previously described and depicted in **Figure 7-3**, the buildout effluent or reclaimed water supply is projected to exceed the estimate of future reclamation demand. Therefore, reclamation demands will be able to be met on a daily "on-demand" basis under future conditions. Effluent will be used to supply the reclamation system directly as it is produced, and only daily storage or operational adjustments will be needed to supply PHD.

The City's ability to supply recycled water to off-site use areas on-demand is limited by the capacity of the RBPS and upstream EPS. Assuming the capacities of these pump stations are increased to meet demand requirements (as they will be), the tertiary treatment capacity of the WWTRF will govern the ability of the system to supply recycled water on-demand. Treatment facilities downstream of the maturation ponds have a capacity roughly equivalent to peak month wastewater flow, which is estimated to exceed PHD for reclaimed water at buildout.

Peak hour storage volume is calculated based on the estimated recycled water demand of the potential users and their associated diurnal use patterns. Based on the assumption carried through this Master Plan that the majority of future reclamation uses will be for irrigation, only using recycled water over an 8-hour demand period (most likely to occur at night), it can be calculated that the peak hour storage needs to be sized for 30 percent of the maximum monthly demand (MMD). An additional consideration is whether the County claims their portion of effluent as it is produced[8]. If the county does not claim their portion of effluent, this effluent stream may be utilized by the City of Lincoln, limiting the capacity required for peak hour storage. The estimate of extra storage to meet PHD flow, in contrast to direct effluent

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[8] The values presented here assume that the County claims their share of reclaimed water and that it is not available to meet City demands.

production at the WWTRF, includes a 10 percent allowance for operational flexibility. For example, if the peak irrigation rate is 18 MGD, Peak Hour Storage could be about 5 MG.

The need for peak hour storage capacity is also dependent WWTRF operations. Operations of the WWTRF could be adjusted to accommodate reclamation demands. The WWTRFs maturation ponds allow water to be stored ahead of tertiary treatment with almost 100 MG of wet weather flow equalization capacity that can be used for peak hour storage during the summer. Allowing daily storage in the maturation ponds and performing tertiary treatment on-demand would eliminate the need for daily storage facilities. The 5 MG identified above is if there are no operational adjustments and the existing tertiary facilities operate as they do currently, with a continuous 24-hour steady treatment of equalized flow. However, with operational adjustments, the 5 MG peak hour storage capacity can be provided by utilizing the available volume in the maturation ponds.

Alternatively, daily storage volume can be obtained within the TSBs but, these basins are very large and subject to algae growth in the summer. Utilizing TSB volume would require the use and expansion of retreatment facilities (DAFTs[9]) to remove algae, to accommodate the projected reclamation PHD. The use of DAFTs is the current practice for using TSB stored effluent for reclamation. Therefore, no new peak hour storage is anticipated to be needed to fulfil the needs of this Reclamation Master Plan at build out flows with the proper addition of DAFTs and/or operational adjustments as the WWTRF expands.

The preceding discussion aims to identify the reclamation storage and peak hour storage issues that must be considered in the development of this master plan. However, the results of the storage analysis indicate that no new storage requirements are required at buildout conditions than those that will be provided for effluent management or for the maturation ponds.

From current to buildout conditions, it is anticipated that effluent supply will increase in proportion to new reclamation demands as the City grows and that, therefore, the above storage conclusions hold true for interim levels of development. However, any accelerated development of reclaimed water demands in contrast to the rate of production of effluent could require additional reclamation storage. Supply and demand asymmetry is not anticipated, but the water balance and reclamation needs of the facility should be reassessed periodically to ensure that the City can always meet reclamation commitments.

7.6 SUPPLY AND STORAGE RECOMMENDATIONS

7.6.1 Available Supply

Based on the preceding discussion and existing water planning, the WWTRF will produce more than enough effluent to supply future reclamation demand projections. The planned TSB volume is adequate to provide seasonal storage of recycled water. Because future demands are projected to be less than the existing reclamation demand, additional storage may be

[9] DAFTs = Dissolved Air Floatation Tanks

needed under interim conditions if the City chooses to supply demands higher than those projected by the water balance evaluation. Higher demands were not considered as part of this master plan or water balance update.

7.6.2 Effluent Management

As previously discussed, the City's future reclamation demands are projected to account for only a portion of the WWTRF's total effluent volume. The City should pursue additional planning to ensure that effluent can be properly managed as additional development occurs. The existing storage and effluent management facilities can support interim conditions throughout the construction of the WWTRF Phase I and Phase II expansion projects assuming that the WWTRF takes fully utilizes its ability to discharge effluent to Auburn Ravine, utilizes the RSB as additional storage capacity, and reclamation demands are not reduced below current levels.

The City should consider additional disposal methods and/or increase the capacity of existing disposal methods. If temperature impacts to Auburn Ravine were not limited by the NPDES Permit, all excess effluent could be discharged to the creek, assuming compliance with other regulatory limitations (WW0066). The City should pursue improvements that allow a larger volume of discharge to Auburn Ravine, the installation of effluent cooling facilities to mitigate temperature impacts, and/or identify additional reclamation demands outside of the City SOI.

The City's existing regional wastewater treatment agreement with Placer County allows the County to claim their portion of reclaimed water. Any unclaimed recycled water further supports the redundancy of Lincoln's non-potable water supplies and increases the scale of effluent management facilities and the need for planning. Projecting the use patterns, demands, and infrastructure needs for regional entities to claim their portion of recycled water is outside the scope of this Master Plan. Although, the existing 24-inch pipeline in Fiddyment Road, currently supplying recycled water to the Machado Farm and the County Irrigation site, could be used to transmit water south to Placer County's Placer Ranch development or other industrial users in the area of Athens Avenue in the future.

7.6.3 Demand Prioritization

To further support effluent management efforts, the City should prioritize additional uses based on the service expansion cost and added rate of demand. The unit cost of building the required infrastructure to serve a new use area, expressed in capital dollars per acre-foot served, is a good basis for prioritizing system expansions. Typically, large users are more cost-effective to add than small users are, unless distance and/or elevation make service cost prohibitive.

The usage pattern of the proposed use should also be considered in prioritization. Customers with large consistent demands function as a reliable base for the recycled water system, smaller users located throughout the distribution system are typically added later. Non-irrigation customers, such as industrial uses, provide a baseload demand that can take supplies during times of otherwise minimal use. They can reduce the amount of storage needed to supply daily demand fluctuations. Baseload customers also improve the overall system hydraulics and reduce surges and large pressure fluctuations in the distribution system.

In summary, the City should prioritize additional users based on the associated cost per acre-foot served ($/AF), total reclaimed water demand, and demand usage pattern. Potential uses with low cost to provide service, high usage, and consistent demand usage patterns should be priorities for the City.

7.6.4 Interim Conditions, System Redundancy, and Reliability

The City has reliable and redundant water supplies, as described in **Chapter 4.0**. Water supply sources include groundwater, raw water, and recycled water supplies. To phase out agricultural uses and supply future demands as they develop, higher than projected recycled water demands may need to be supplied. It could also be the case that the demand for recycled water increases at a higher rate than the WWTRF's ADWF and effluent production rate. The City could supplement interim supply deficits with an alternative make-up water source for the purpose of maintaining system reliability. Maintaining a reliable system will allow the reclaimed water system to continue to grow and add customers. This approach would allow the City to maximize effluent flow from the WWTRF throughout the year and minimize the need for daily recycled water storage and retreatment facilities.

Providing an additional supply source to the system has the added benefit of ensuring a reliable water supply to customers. It eliminates the expense for each customer to have a backup water supply, which is required to be fitted with extensive cross-connection facilities. This would allow connection of users without fear of supply limitations and further reduces the risk of cross-connections between the City's potable and recycled water supplies. This could make recycled water a more attractive non-potable water supply source within the community when compared to other available sources.

There are a number of agricultural wells within the City's SOI that could potentially be used to augment the reclamation system in the future. These wells could be preserved as development occurs through strategic planning for use as non-potable supply wells. The reclamation system should be supplied primarily with recycled water and could be supplemented with raw water to enhance system reliability and supply peak demands.

The following is recommended to the City to ensure that effluent is properly managed as further growth occurs:

- The development of an Effluent Management Master Plan
- Encourage Placer County to retrieve their portion of effluent (COJA)
- Increase the allowable discharge to Auburn Ravine.
- Add industrial customers providing a larger baseload demand during times low irrigation.
- Expand reclamation demands (through Village 1, 2, and 3, or outside the SOI)

8.0 PLANNING AND EVALUATION CRITERIA

8.1 PURPOSE

The purpose of this chapter is to present the reclamation system planning approach, recommended system specifications, and the planning and evaluation criteria used to identify capacity deficiencies within the existing reclamation system. The evaluation criteria are also used to determine the layout and capacity needs of the future system and estimate buildout infrastructure requirements which are used to develop planning level opinions of probable cost. The system improvements and capital improvement projects (CIPs) presented in this Master Plan have been developed on the basis of providing sufficient system capacity and infrastructure performance to meet level of service (LOS) criteria.

This chapter is divided into the following sections:

- System Planning Approach
- Level of Service Criteria & Key Performance Indicators
- System Specifications and Considerations

8.2 SYSTEM PLANNING APPROACH

The approach to reclamation system planning is to supply the reclamation system without any remote storage or pumping facilities for future developments or pressure zones within the distribution system. This Master Plan assumes the distribution system will be supplied entirely by the RBPS and on-site storage and/or production at the WWTRF. Limiting storage and pumping to the WWTRF site provides economy of scale in operation and maintenance costs associated with the facilities. Onsite storage and booster pumping facilities can be implemented at use sites but at the expense and operation of the recycled water user.

The recycled water service area is limited to the western portion of the City planning area due to the relative availability of alternative non-potable water supplies in the area. In addition, the exclusion of relatively higher elevation areas in the east provides consistent system specifications and limits overall pumping requirements. System specifications and pumping requirements presented in this Master Plan should be revisited should the City choose to expand this service area beyond the bounds identified herein.

8.3 LEVEL OF SERVICE CRITERIA & KEY PERFORMANCE INDICATORS

Key performance indicators are used to define the level of service (LOS) that the future reclamation system must achieve. The key performance indicators used to define the required LOS of the reclamation system include distribution system pressures, pipeline velocity and headloss, as well as RBPS pumping capacity.

8.3.1 System Pressures

Th recycled water system pressure is ideally designed to operate at a slightly lower pressure than the potable water system. This pressure differential reduces the risk of contaminating the potable water system in the event that a cross-connection exists between the two systems or an adjacent recycled water main is broken.

However, this requirement often cannot be met due to:

- Water system pressure variance geographically and as system demands fluctuate,
- The fact that water treatment plants are typically located at high points within the community and wastewater treatment plants are typically located at low points; and
- The need for a minimum pressure of 60 psi to meet the operating requirements of most sprinkler systems on the reclamation system.

The risk of a cross-connection between the recycled water and potable water systems is minimized by maintaining a minimum horizontal separation standard of 10-feet and installing backflow prevention devices, swivel-el connections, and/or pressure reducing valves at connections to the large transmission mains as required. At locations of use downstream from the reclamation mains and pressure reducing stations, pressures will ideally be lower than nearby potable systems. Cross connection prevention tests are also required as part of the City's reclaimed water permitting process.

Therefore, the layout of the future recycled water system is not coordinated with the existing potable water system layout and pressure ranges. The minimum system pressure used to size a new system pipeline is 60 psi under peak hour demand (PHD) conditions, with a target system operating range of between 60 and 100 psi. Due to limitations with the existing reclamation system, a minimum pressure of 50 psi is allowed for services off the existing system. Customers who need a higher pressure can install booster pumping systems at their own expense

8.3.2 Pipeline Sizing Criteria

Pipeline sizing is based on the following key performance indicators:

- Demand Conditions
- Pipeline Velocity
- Pipeline Headloss

Pipe sizes are selected so that they do not exceed velocity and headloss criteria under PHD conditions. When a pipeline is projected in the model to exceed the velocity or headloss criteria it is upsized to the next standard size, even if this means the selected pipe size operates at less than the pressure criteria. The focus of the system evaluation and planning presented in this Master Plan is on recycled water transmission mains. Any pipeline 8-inches in diameter or larger is considered to be a transmission pipeline, while pipelines that are 6-inches in diameter or less are considered distribution pipelines. Distribution pipelines within the system are considered on a case by case basis.

Pipeline Velocities

The maximum velocity within new pipelines should not exceed 4 feet per second (fps) under PHD conditions in transmission mains. The maximum pipeline velocity in existing distribution mains, should not exceed 6 fps under PHD.

Pipeline Headloss

Pipeline headloss should not exceed 0.005 ft/ft under PHD conditions. A summary of pipeline evaluation criteria for PHD conditions is provided in **Table 8-1**.

Table 8-1 Reclamation System Pipeline Evalation Criteria

Criteria	Existing Pipelines	Proposed Pipelines
Pipe Sizes (in)	4, 6, 8, 12, 14, 16, 18, 24	8, 12, 14, 16, 18, 24, 27, 30, 36
Maximum Design Velocity	6 fps	4 fps (pipelines 8-inches and larger)
Delivery Pressure	60 (50 off existing system) – 100 ± psi	
Headloss	< 0.005 (ft/ft)	
C (Hazen-Williams Friction Factor)	150 (PVC)	

8.3.3 Pump Station Sizing Criteria

The reliable pumping capacity of the RBPS needs to be sufficient to serve the PHD with the largest pump out of service, so that one pump unit can be designated as a spare to accommodate repairs and maintenance activities without interruption of system operations.

The existing RBPS is arranged to accommodate six pumps and five currently installed. The site arrangement accommodates the construction of a parallel wet-well of the same capacity. Long term, to meet PHDs, the existing RBPS pumps may need to be replaced with pumps having approximately 30% higher pumping capacity. Ideally demands will increase over many years and pump capacity requirements can be reevaluated and expanded at the time that each existing pump reaches the end of its useful life and needs replacement, making the upsizing a standard event with no through-away equipment.

An additional element of pump station expansion is to provide sufficient wet-well operating volume to allow the pump station to respond to changes in demand quickly without having an equally rapid change in the effluent treatment rate. The wet-well volume will need to be adequate to accommodate the operational requirements of the overall reclamation system.

One option to expand wet well capacity is to tie-in the pump station influent piping directly to the plant clear well in addition to the existing connection to the effluent pump station wet-well.

This will allow the operating volume of the clear well and unused reaeration basin to be used by the RBPS. Design details and timing should be considered as expansion of the reclamation system and WWTRF occurs.

8.4 SYSTEM SPECIFICATIONS AND CONSIDERATIONS

8.4.1 Pipelines

Pressure Class

New pipelines should consist of purple C900/C905 PVC with restraints and cathodic protection on buried metal fittings. The dimension ratio and pressure class is recommended to be DR 14 – 305 psi. Although DR 18 – 235 psi was determined to be acceptable and used for the Phase I Reclamation project, a higher pressure class is recommended for pipelines at lower elevations. Using a higher pressure class on these pipelines will allow the City to install much larger head pumps at the RBPS in the future if they choose to supply demands at higher elevations.

Converted Wastewater Forcemains

Portions of the distribution system consist of converted wastewater forcemains that were abandoned when the associated wastewater pump station was decommissioned. These portions of the system can be identified within the record drawings of the Phase I Reclamation Project. The portions of the system consisting of converted wastewater forcemain should be replaced first as part of an overall repair and replacement program for the reclamation system. These portions of the system are the oldest and the materials are inconsistent with the remaining system.

8.4.2 Valves and Surge Protection

Slow Close Valves

Water hammer is the result of a pressure surge, or high-pressure shockwave that propagates through a piping system when a fluid in motion is forced to change direction or stop abruptly. This can occur when large demands come on and off within the system. To reduce water hammer and provide surge protection it is recommended that slow-close valves are specified along transmission mains (≥ 10-inches) within the distribution system.

Pneumatic Tank

The existing RBPS includes a 10,000-gallon pneumatic tank to regulate pressure within the recycled water distribution system. The operation of this pneumatic tank should be considered as the distribution system is expanded and new demands are added to the system. Capacity of the pneumatic tank should be evaluated as part of future RBPS improvement projects.

8.4.3 Use Area Considerations

The customer or owner shall be responsible for the safe and efficient operation, maintenance and upkeep of their on-site facilities. All recycled water users should refer to the *City of Lincoln – Rules and Regulations for Recycled Water Use and Distribution* (included as **Appendix A**) which establishes procedures, specifications, and limitations for the safe and orderly development and operation of recycled water facilities and systems in the City of Lincoln.

Any off-site recycled water distribution facilities, to the extent determined by the City, required to serve developments in the City service area shall be provided by the applicant, owner, or customer at their expense, unless the City determines it is appropriate to construct these capital facilities. Plans and specifications for all recycled water distribution facilities shall be submitted to and approved by the City in advance of construction. The City will assume responsibility for providing recycled water service to the point of connection of such development upon transfer to the City the title to all off-site recycled water systems and any necessary easements. All easements shall be in a form acceptable to the City and not subject to outstanding obligations to relocate such facilities or any deeds of trust, except as approved by the City.

Off-site facilities for use areas may include the recycled water meter, filter, pressure reducing valve, and swivel-ell connection. These improvements were required at Parks included as part of the Phase II Reclamation Project. An inline filter was needed to help protect and minimize maintenance of onsite irrigation systems, which have small emitters which can easily become clogged. The Phase II improvements included the installation of a valve vault and spool for the future installation of a pressure reducing valve depending on future pressure conditions within the recycled water distribution system.

To ensure consistent irrigation of these large parks within the City, a potable water connection was required to provide an auxiliary water supply. The potable water connection required air-gap separation and the use of a swivel-ell connection. As described in **Section 3.3**, the *City of Lincoln Code Section: 13.05.030 – Protection Required*, describes the City's potable water protection facilities required for use areas that use potable water as a backup water supply. A swivel-ell connection is authorized air gap cross-connection control for non-dual plumbed systems. A swivel-ell connection shall be designed to preclude the simultaneous use of both potable and reclaimed water sources to supply a distribution system. The swivel-ell may be manually switched between the reclaimed water source connection and the potable water source connection to supply the use area's distribution system. An example of the swivel-ell air gap connection is shown as **Figure 8-1**.

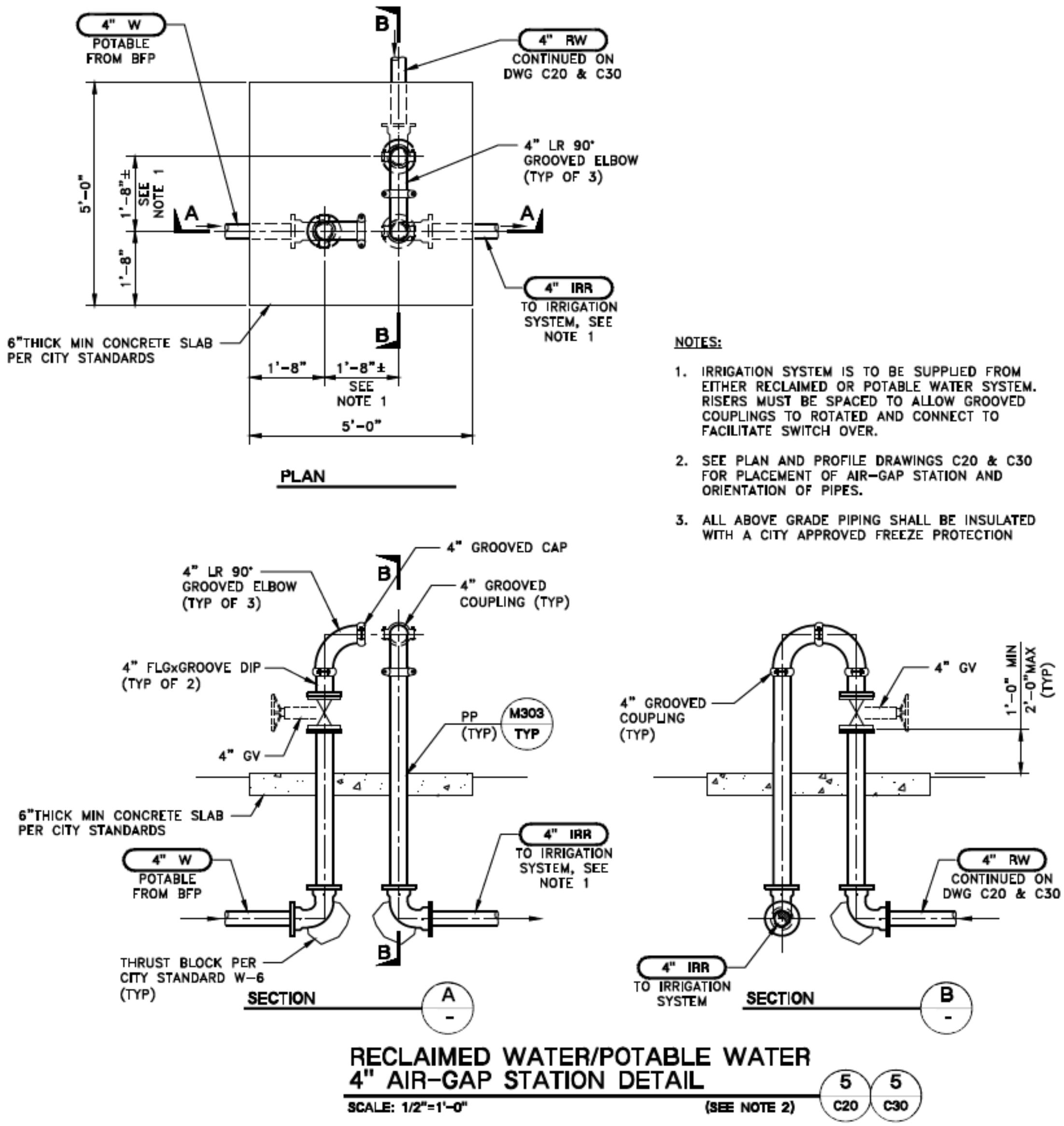


Figure 8-1 Swivel-Ell Air Gap Connection Detail

9.0 HYDRAULIC MODEL DEVELOPMENT

9.1 PURPOSE

The purpose of this chapter is to outline details of the recycled water distribution system model construction and approach. This chapter also describes the model scenarios considered as part of this Master Plan representing various levels of development within the City.

This chapter is divided into the following sections:

- Model Approach
- Modeling Software
- Model Input and Components
- Model Development
- Model Calibration
- Modeled Scenarios

9.2 MODEL APPROACH

Hydraulic modeling is an important tool used to simulate and analyze water systems and their operation. There is a wide selection of software programs that have made network analysis modeling efficient and practical for virtually any water system. Modeling can simulate existing and future water system conditions, identify system deficiencies, analyze impacts of increased demands, and evaluate the effectiveness of proposed system improvements. Hydraulic models can provide both the engineer and water system operator with a better understanding of the water system operating and hydrodynamic conditions.

9.3 MODELING SOFTWARE

There are several software programs that are widely used to model pressurized distribution systems. The variety of the program capabilities and features makes the selection of a particular modeling software generally dependent upon three factors: user preference, the requirements of the particular water distribution system, and the costs associated with the software.

Although multiple software packages are available, WaterCAD by Bentley has been determined to best meet the City's modeling needs, as it is simple to operate and has relatively low costs. If the City were to want to operate their own model, this would be an efficient choice. The City's existing WaterCAD model was originally developed as part of the 30% Master Plan. The model simulates conditions in the recycled water distribution system and was updated for use with the development of this Master Plan.

9.4 MODEL INPUT AND COMPONENTS

A hydraulic model is composed of three main parts:

1. The data file that stores the geographic location of facilities. The geographic data file provides water system facility locations and is typically represented as an AutoCAD drawing file or GIS shapefile. Elements in this file represent model system facilities including pipes, junction nodes (connection points for pipes and locations of demands), control valves, pumps, tanks, and reservoirs.

2. The physical attribute database that defines the physical system properties, including things such as the facility size and geometry, operational characteristics, and production/consumption data.

3. A computer program "calculator" that solves a series of hydraulic equations based on the information contained in the database files to find and generate the performance of the water system in terms of pressure, flow, and operation status.

The key to maximizing the benefits of developing a hydraulic model is correctly interpreting the results so the user understands how the distribution system can be affected by the variables input into the model. This understanding enables the user to be proactive in developing solutions to existing and future water system goals and objectives. With this approach, the hydraulic model is not only used to identify the adequacy of system performance, but it is also used to find solutions for operating the water system according to established performance criteria.

Developing an accurate and reliable hydraulic model begins with entering system infrastructure information into the database and calibrating the model to match existing conditions observed in the field. Once the model is calibrated, it becomes an invaluable tool that can be used to solve system planning and operational issues. The model operates according to the operational and physical attributes assigned to each model component. This information is used to simulate flow and pressures within the system as predicted by the model's mathematical equations.

The hydraulic model used to develop the City's 30% Reclamation Master Plan was reconstructed using data provided by the City in the form of an ArcGIS geodatabase file:

- Reclamation.gdb (1/17/2018)

The file provides the physical attributes and location of the valves and pipelines within the existing reclamation system. Manufacturer pump curves and physical parameters of the reclamation booster pump station (RBPS) pumps were also used to create the hydraulic model.

9.5 MODEL DEVELOPMENT

The City's existing reclamation system model was updated with information provided by the City (as-built infrastructure and service area geography). After reviewing the information provided by City staff, the hydraulic model was updated to represent actual parameters associated with each system asset. Either a model link, node, pump, or valve is used to represent each system asset within the model. Associated physical and operational data for each component is stored as an attribute table assigned to each link or node.

Nodes are used to represent connections between links and may act as either a supply source, such as a tank, reservoir, hydrant, or a customer demand. Nodes define the boundaries of each link and separate links that may contain different attributes. Essential attributes input into the database associated nodes include elevation, flow demand, and pressure zone. Resulting node parameters calculated by the model include pressure and hydraulic grade line.

Pumps and valve elements are used to represent pumps, pump stations, and valves within the distribution system and require input of attributes associated with operational and physical data of the system component.

Links represent pipe segments and input of attributes such as diameter, length, and Hazen-Williams C-factor. Flow, velocity, headloss, and changes in hydraulic grade line are some of the reported output parameters for all link elements.

9.6 MODEL CALIBRATION

Once the model was redeveloped and updated, it was calibrated so that it provided a reasonable representation of actual field performance. Existing operation data was used to calibrate the model. During calibration, parameters in the computer model are adjusted so hydraulic results are similar to observed measurements in the field under identical conditions. Once calibrated, the model is an effective tool for predicting system performance under different demand or operational conditions.

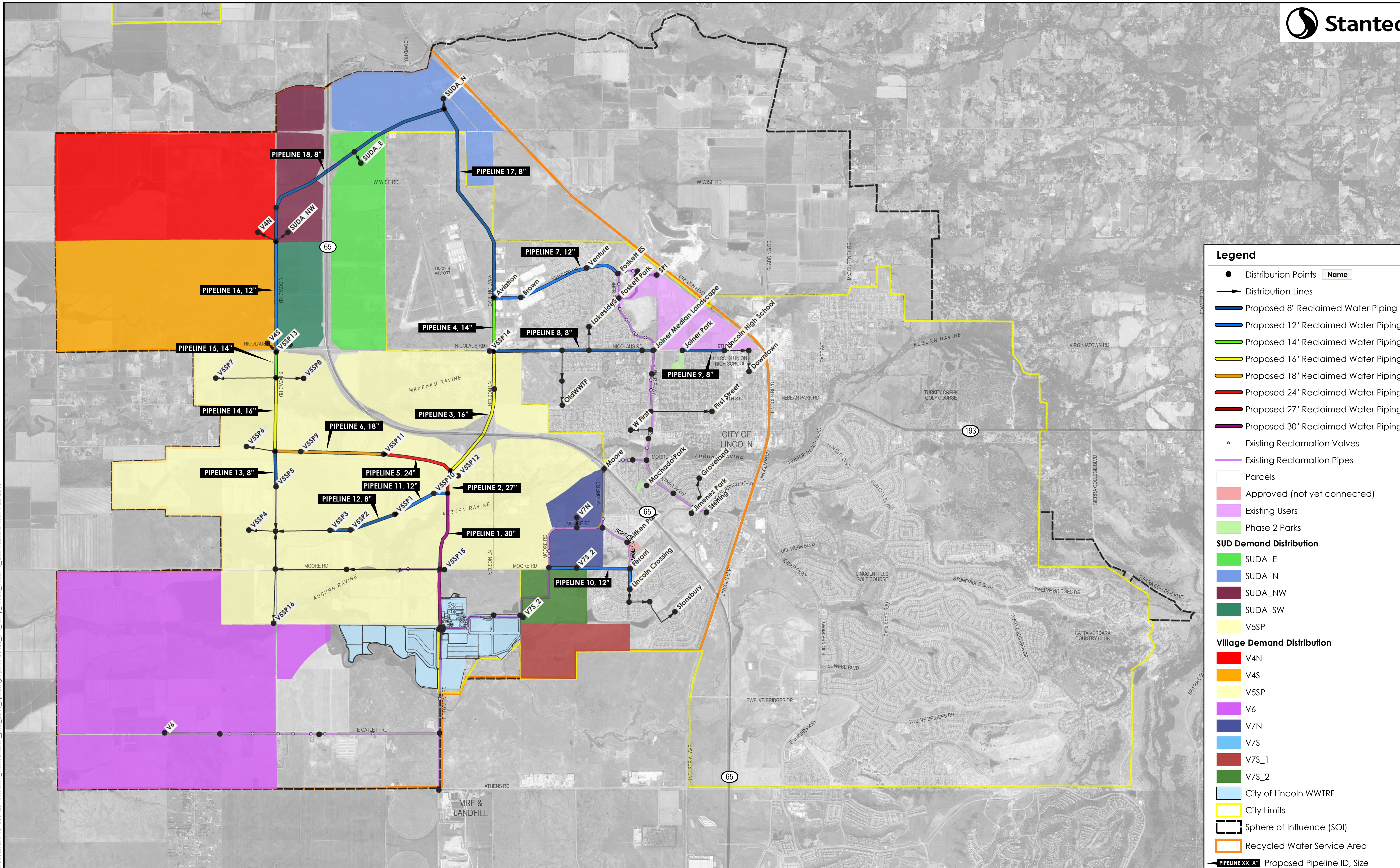
9.7 MODELED SCENARIOS

The calibrated model only represents the existing recycled water system infrastructure. However, the main purpose of the development of the hydraulic model is to create a tool that can be used to size future system expansions and develop the recommendations presented in this Master Plan. The existing system model was used as a basis to create model scenarios of the system under various levels of community development. To create the future system scenarios, new pipelines, nodes, user demands, and facilities were added to the system model. Controls from the existing calibrated model were imported and modified as necessary to create simulations of the future system.

The existing hydraulic model includes the following scenarios:

1. **Existing Level of Development Scenario**
    a. Existing Scenario – PHD
    b. Existing Scenario – MMD
    c. Existing Scenario – ADD
2. **Near-Term Level of Development Scenario**
    a. Near-Term Scenario – PHD
    b. Near-Term Scenario – PHD - 5p (all five pumps in operation)
    c. Near-Term Scenario – PHD – Remove County Leased Reclamation Area
    d. Near-Term Scenario – MMD
    e. Near-Term Scenario – ADD
3. **Buildout Level of Development Scenario**
    a. Buildout Scenario – PHD
    b. Buildout Scenario – MMD
    c. Buildout Scenario – ADD
4. **Long-Term Level of Development Scenario**
    a. Long-Term Scenario – PHD
    b. Long-Term Scenario – MMD
    c. Long-Term Scenario – ADD

Figure 9-1 depicts how the demands were distributed within the hydraulic model. Demands within Village 5/ SUD-B were distributed based on those presented in the Specific Plan. Demands to other service areas are assumed to be distributed uniformly and are collectively served by the nodes identified on the nearest distribution main.



City of Lincoln
Reclamation Master Plan

Figure 9-1
Model Demand Distribution

10.0 RECLAMATION SYSTEM EVALUATION

10.1 PURPOSE

This chapter evaluates the existing reclaimed water system to identify issues that must be resolved for continued system operation and for preparation of future system expansions. This chapter also presents the proposed approach to phasing the construction of future recycled water distribution mains needed to provide reclamation service within the recycled water service area.

This chapter is divided into the following sections:

- Existing System Evaluation
- Future System Evaluation
- Phasing Approach

10.2 EXISTING SYSTEM EVALUATION

10.2.1 Existing Scenario

The hydraulic analysis of the existing reclaimed water system is based on the results of the calibrated model of the existing system. The hydraulic model was used to evaluate the existing reclamation system for possible deficiency corrections and optimization under the following demand conditions:

- Average Day Demand (ADD)
- Maximum Month Demand (MMD)
- Peak Hour Demand (PHD)

As explained in **Chapter 6.0**, Maximum Day Demand (MDD) conditions are assumed to be the same as MMD conditions. The goal of the hydraulic analysis is to identify system improvements required for efficient system operation and increased system utilization in future expansions. The model was run under ADD conditions to estimate the maximum pressure conditions that may occur in the existing system. Under ADD conditions two of the five RBPS pumps operate to supply demands. The pressure in the system ranges between 64 and 88 psi depending on location and elevation.

Based on discussions with WWTRF operators, existing agricultural demands are supplied on a continuous basis (multiple days of 24-hour use) during the maximum month of use. These users serve as large baseload demands, accounting for over 95% of the existing MMD. Because there is no hourly difference in these demands, the results of the MMD and PHD conditions models show little variation. System pressure ranges between approximately 52 and 74 psi with four of the five RBPS pumps running (reliable capacity). With all five pumps running, the pressure range increases to approximately 65 to 88 psi. No deficiencies within the existing system were predicted by the model. Model results are summarized in **Table 10-1**.

Table 10-1 Existing System Model Results Summary (1)

Item	AAD	MMD	PHD
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps
No. of Pumps Operating	2	4	4
Demand (gpm)	1,820	4,550	4,590
Demand (MGD)	2.62	6.55	6.61
Annual Demand Volume (MG)	957	-	-
Maximum Pressure (psi)	88	74	73
Minimum Pressure (psi)	64	52	52
Maximum Headloss (ft/ft)	0.002	0.003	0.003
Maximum Velocity (fps)	1.79	4.47	4.47

1. Existing model results do not include demands associated with Foskett Regional Park, which was connect during the development of this Master Plan.

10.2.2 Near-Term Development Scenario

A near-term level of development scenario was considered within the existing system model. The near-term scenario provides an evaluation of the system upon connection of the City's planned or approved use areas. Demands added to the existing system model include the following park irrigation areas:

- Foskett Park – Approved for recycled water use
- Aitken Park – Approved for recycled water use
- Joiner Park – Phase II Reclamation Project
- Machado Park – Phase II Reclamation Project
- Peter Singer Park – Phase II Reclamation Project

The MMD of these parks adds an additional 565 gpm to the existing system demand, and 1,695 gpm to the total PHD. The total MMD and PHD exceed the current reliable pumping capacity (four pumps in operation) of the RBPS. The system pressure range is projected to fall to approximately 42 to 65 psi, under MMD conditions. Pressures are further reduced within the system under PHD conditions, falling to a minimum pressure of approximately 17 psi near Foskett Regional Park. Generally, lower pressures are projected along the 12-inch Joiner Parkway pipeline, and higher pressures are predicted at lower elevations in the system near the WWTRF.

The PHD exceeds the maximum pumping capacity of the RBPS (five pumps in operation). Existing demands can be met, but at the expense of system pressure and pump station redundancy. Based on discussions with City staff, the County Leased Reclamation Area may be removed from the reclamation system within the next five years. With the demand of the County Leased Reclamation Area removed from the model, system pressure range increases to approximately 45 to 77 psi with four of the RBPS pumps in operation. A summary of model results is presented in **Table 10-2**.

Table 10-2 Near-Term System Model Results Summary

Item	AAD	MMD	PHD
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps
No. of Pumps Operating	2	4	4
Demand (gpm)	2,046	5,115	5,985
Demand (MGD)	2.95	7.37	8.62
Annual Demand Volume (MG)	1,075	-	-
Maximum Pressure (psi)	78	65	50
Minimum Pressure (psi)	54	42	17
Maximum Headloss (ft/ft)	0.001	0.003	0.003
Maximum Velocity (fps)	1.79	4.47	4.47

10.2.3 Existing and Near-Term System Recommendations

Condition Assessment – The City should perform a condition assessment of the existing reclamation system. The condition assessment should include a field evaluation of key system assets. Data from the condition assessment can be used in the implementation of asset management software, which can provide the City with automated evaluations of the most cost-effective means of maintaining the City's recycled water system and prioritizing potential rehabilitation and replacement (R&R) projects as the system ages.

Phase Out County Leased Reclamation Area – The City has identified that the County Leased Reclamation Area may be removed from the reclamation system by 2023. The near-term PHD falls within the existing reliable pumping capacity of the RBPS when the demand of the County Leased Reclamation Area is removed from the model. Alternatively, the City could install 6th RBPS pump to provide reliable pumping capacity during PHD conditions. Additional operational configurations include:

1. The 45-psi pressure is less than desirable, but suitable for sprinkler operation. The City could use the redundant pump to increase pressures and only drop to 45 psi when a pump is offline for service (don't retain the redundant pump off-line until needed).

2. The Machado irrigation system will take as much water as the City can send them. The City could send slightly less water to Machado to achieve the desired pressures in the City.

10.3 FUTURE SYSTEM EVALUATION

10.3.1 Buildout Development Scenario

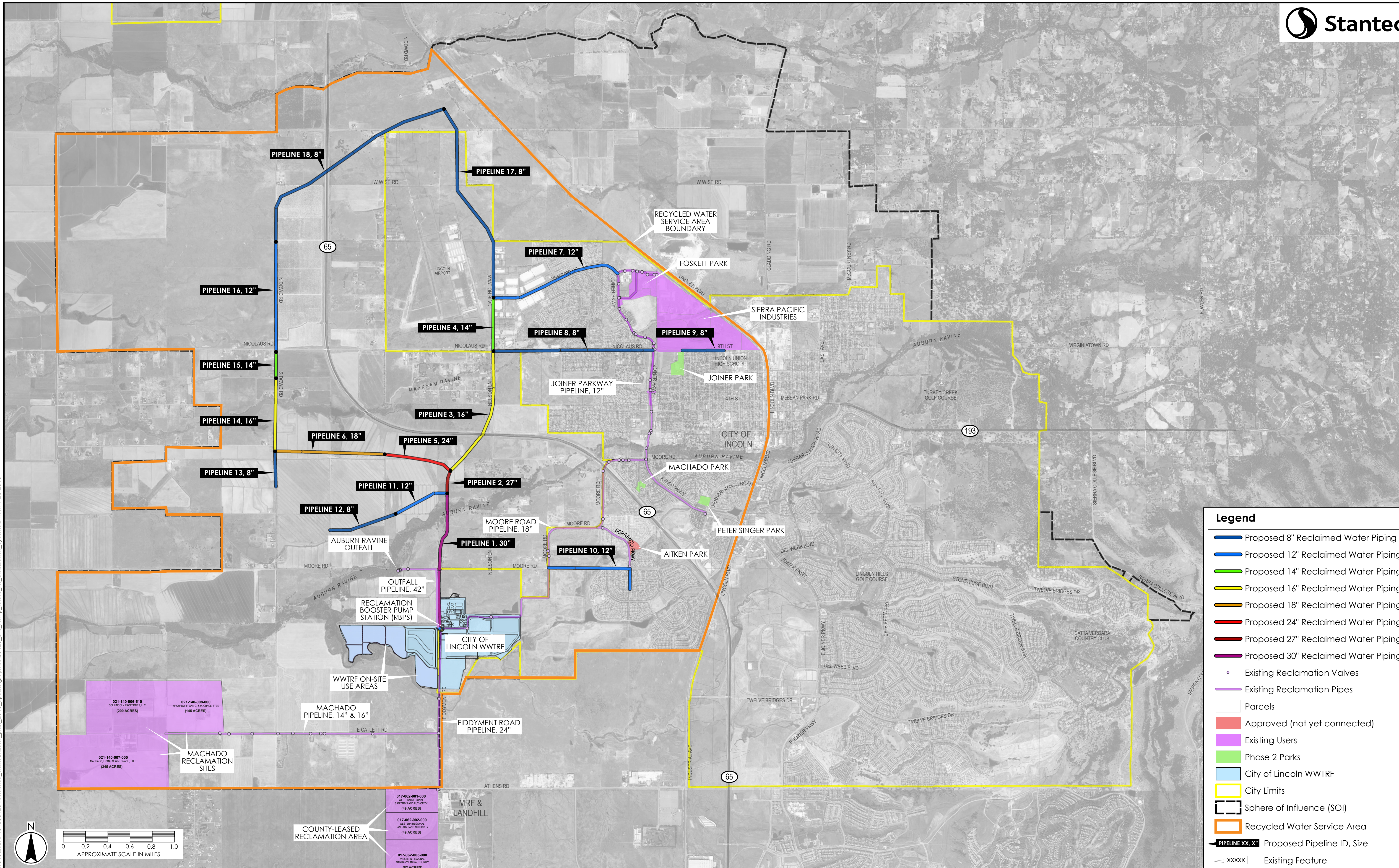
Using information from previous chapters, the future system evaluation builds on the existing hydraulic model to develop potential system expansion alternatives that are within demand, supply, and evaluation criteria constraints. The existing system model was expanded to include demands associated future users within the City and proposed developments within the SOI. The demands of existing agricultural users are excluded from the buildout model because they will be phased out upon development of the SOI areas. The results of the simulations are used to size infrastructure required for future system expansions.

The first step in planning the future system is the development of the initial layout of the distribution system, which was previously considered as part of the 30% Reclamation Master Plan. The pipeline alignments were laid out to follow future roadway corridors presented in the City's General Plan and to maximize efficient supply and minimize cost. The future distribution system was adjusted to eliminate proposed facilities outside of the revised recycled water service area. The remaining pipelines were adjusted to support updated demand estimates and distribution needs. The revised system layout includes nineteen new pipeline segments. The future pipelines are shown on **Figure 10-1**. Pipeline diameter, length, and service area are presented in **Table 10-3**.

Table 10-3 Future System Pipelines

Pipeline ID	Length (ft)	Pipe Size (in)	Service Areas
1	7,000	30	V-4, V-5/SUD-B, SUD-A, Existing City
2	1,000	27	V-4, V-5/SUD-B, SUD-A, Existing City
3	7,000	16	V-5/SUD-B, SUD-A, Existing City
4	3,000	14	SUD-A, Existing City
5	3,000	24	V-4, V-5/SUD-B, SUD-A
6	5,000	18	V-4, V-5/SUD-B, SUD-A
7	6,000	12	Existing City
8	8,000	8	Existing City
9	2,000	8	Existing City
10	5,000	12	V-7, Existing City
11	3,000	12	V5/SUD-B
12	3,000	8	V5/SUD-B
13	2,000	8	V5/SUD-B
14	4,000	16	V-4, V-5/SUD-B, SUD-A
15	1,000	14	V-4, SUD-A
16	5,000	12	V-4, SUD-A
17	10,000	8	SUD-A
18	11,000	8	V-4, SUD-A
19	3,000	14	V-6
Total	**89,000**	-	-

The ultimate system shown on **Figure 10-1** consists of a looped system, which enhances the overall system reliability.



City of Lincoln
Reclamation Master Plan

Figure 10-1
Future Recycled Water Distribution System

The future system has been sized to accommodate PHDs and will not require storage or pump stations within the distribution system, assuming demands do not exceed those estimated in this Master Plan. The requirements of the future distribution system should be revisited If the City chooses to supply additional demands or expand the proposed service area in the future.

Future demands within the City's recycled water service area reduce the total buildout MMD by 50 gpm and increase PHD by 8,350 gpm when compared to the existing system scenario. MMD is reduced, while PHD is increased due to the loss of large agricultural demands with 24-hour supply cycles and the addition of irrigation demands having shorter supply cycles. The existing RBPS was designed with future expansions in mind, reserving space for an additional wet-well to house six additional pumps. In future system scenarios, the RBPS is assumed to be expanded. Including this wet-well fora total of 12 RBPS pumps which match those currently installed. The reliable capacity of the expanded pump station is approximately 15.9 MGD, and the maximum capacity is approximately 19.0 MGD. A summary of model simulation results is provided in **Table 10-4**.

Table 10-4 Buildout System Model Results Summary

Item	AAD	MMD	PHD	PHD – New Pumps
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS Curve x 1.25, (25% more head and flow)
No. of Pumps Operating	2	4	11	10
Demand (gpm)	1,800	4,500	12,940	12,940
Demand (MGD)	2.59	6.48	18.63	18.63
Annual Demand Volume (MG)	946	-	-	-
Maximum Pressure (psi)	91	81	72	101
Minimum Pressure (psi)	59	49	30 (1)	59
Maximum Headloss (ft/ft)	0.001	0.001	0.004	0.004
Maximum Velocity (fps)	1.85	1.88	5.30	5.30

Expanding the RBPS is only required to meet PHDs under buildout conditions. The reliable pumping capacity of the existing RBPS can supply AAD and MMD at buildout, as they are less than those of the existing system. Similar to the existing system results, minimum system pressures exist at higher elevations, generally north of Nicolaus Road and east of Joiner Parkway. Under PHD conditions at buildout, the minimum pressure within the system is projected to drop to 30 psi, which is below minimum pressure criteria. Depending on the system pressure needs and actual demands within the service area, the City may choose to replace the existing RBPS pumps with higher head versions in the future.

The RBPS pump curves within the model were adjusted to consider the impacts of increasing the RBPS head and flow, the results of this simulation are also shown in **Table 10-4**. The operating point of the RBPS pumps was increased from 1,100 gpm at 180 TDH, to 1,375 gpm at 225 TDH within this scenario. The resulting maximum pipeline velocity and maximum headloss remain within the recommended operating range, occurring within the 18-inch Moore Road pipeline under PHD conditions. Therefore, no pipeline improvements are expected to be needed within the existing system in order to supply buildout reclamation demands with higher capacity pumps. Although, pipeline pressure classes and system operating conditions should be reconsidered when designing RBPS improvements.

10.3.2 Long-Term Development Scenario

To consider interim conditions and assess potential phasing strategies, a "long-term" level of development scenario was considered as part of the future system model. Demands associated with Village 4, SUD-A, and Village 6 were excluded from the model in this scenario. A summary of the long-term model results is presented in **Table 10-5**. The PHD under long-term development conditions exceeds the reliable capacity of the existing RBPS, requiring nine pumps to meet the estimated demand. The system pressure range is expanded by shifting demands to higher elevations.

Table 10-5 Long-Term System Model Results Summary

Item	AAD	MMD	PHD
Pump Curve Used	Existing RBPS pumps	Existing RBPS pumps	Existing RBPS pumps
No. of Pumps Operating	2	3	9
Demand (gpm)	1,482	3,285	9,295
Demand (MGD)	2.13	4.73	13.38
Annual Demand Volume (MG)	779	-	-
Maximum Pressure (psi)	102	82	85
Minimum Pressure (psi)	73	51	40 (1)
Maximum Headloss (ft/ft)	0.001	0.001	0.004
Maximum Velocity (fps)	1.79	1.84	5.17

1. Number of pumps shown to meet flow demanded assume more pumps of the existing pump capacity are added. This results in insufficient pressure indicating that the expanded pumps would require higher head. See **Section 10.3.1**.

10.3.3 Future System Recommendations

The buildout master plan recommendations are developed based on significant assumptions and general planning input, as they are projected to occur well into the future. As a result, the recommendations of the plan and the hydraulic model should be revisited periodically to assess specific plan information as it is developed and becomes available.

In support of expanding reclamation services, the RBPS capacity should be regularly assessed to ensure that reliable capacity is sufficient and maintained at all times. The operation of the

WWTRF should also be evaluated to ensure that PHDs can be met using TSBs and DAFTs or through metered operation of the maturation pond effluent.

For near-term reclamation planning purposes, using Placer County's portion of reclaimed water from the SMD1 wastewater flow contribution can aid in the delivery of PHDs within the service area. However, long term effluent management will become more difficult as flows increase upon future development within the City. Therefore, in the future the City would benefit by having Placer County use their reclaimed water within the County. This possibility should be explored and discussed with the County over time, as it is already a possible provision in the current COJA.

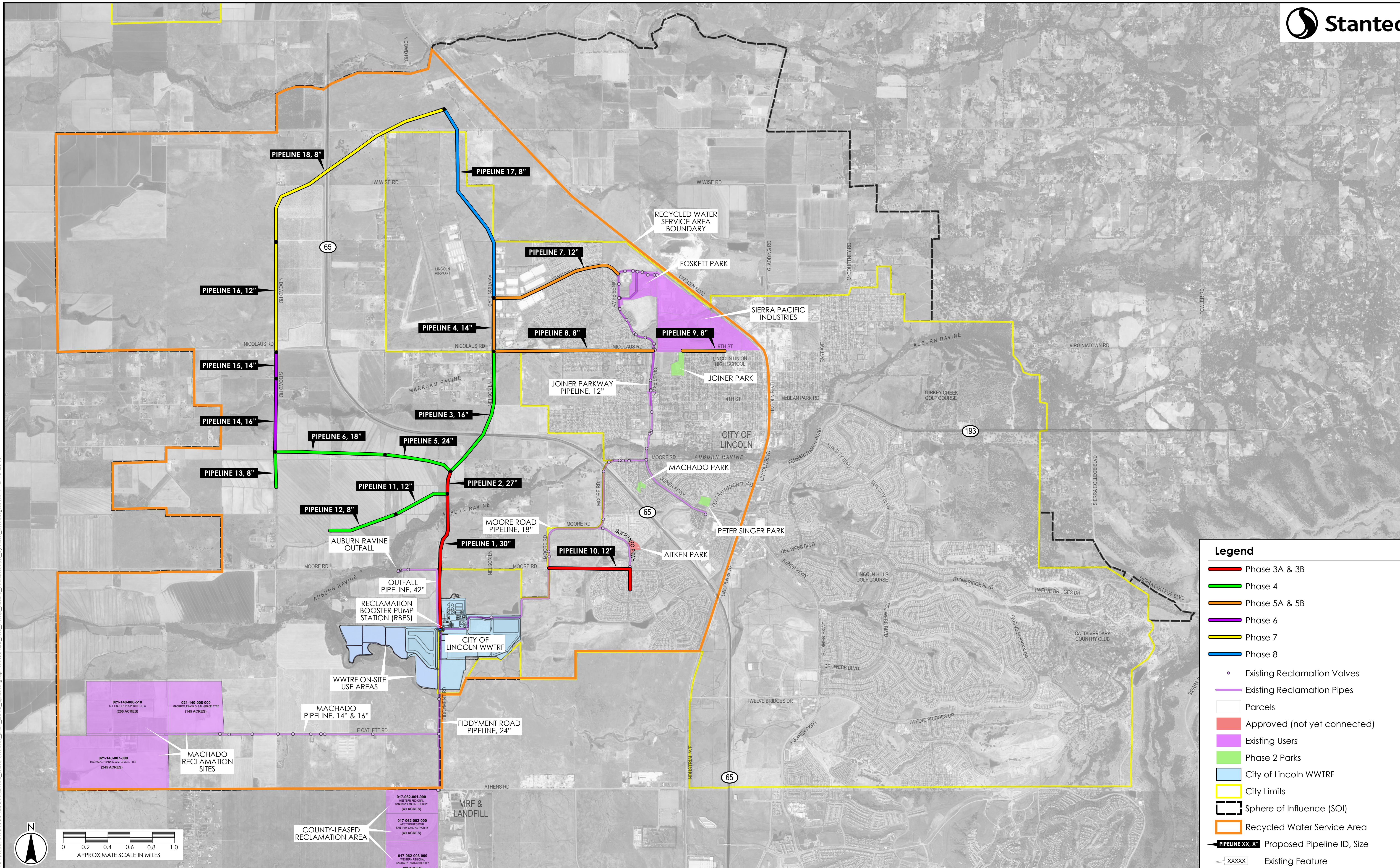
10.4 PHASING APPROACH

The following phasing strategy has been developed considering areas of the City that are currently in development and/or planning and the projected order in which SUDs and Villages may develop. The phasing strategy is subject to change as development occurs and plans become more refined. The actual layout and phasing of the future distribution system will likely be driven by the locations of high demand customers and planned transportation corridors, and the timing of recycled water use commitments. Partnering with users beyond the City's planning area could also influence the layout and stages of construction, although not considered in this Master Plan.

Reclamation phases are numbered in the order in which they are assumed to occur, lettering indicates that phases could occur in either order depending on actual development conditions. The anticipated phases and the corresponding level of development, recommended improvements, demands served, and other recommendations are summarized in **Table 10-6.** The future reclamation system phasing approach is depicted in **Figure 10-2**.

As previously discussed, Phase I improvements have already been completed and Phase II improvements are currently in development and additional users along the existing Joiner Parkway pipeline may also be connected. Phases listed under near-term development conditions support the demands of Village 5/ SUD-B, (currently planning development). Although the recommended projects support demands of areas that were evaluated within the long-term development model, they also support the addition of existing system demands and the first step in providing service to the undeveloped portions of the recycled water service area. Phase 3A pipelines will serve as the primary transmission main for the portion of the service area that is currently undeveloped and provide service to users within Village 5/ SUD-B.

Phase 3B will provide reclaimed water service to users in Village 7 (currently planned for development and recently annexed into city limits) and the existing Lincoln Crossings development. These phases could happen in either order but are considered as the next steps in further expanding the existing system. Along with the construction of the Phase 3B pipelines the City should provide an allowance for the development of an effluent management plan, begin phasing out agricultural users, add the final pump to the existing RBPS wet-well, and conduct an existing system condition assessment.



City of Lincoln
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Figure 10-2
Future Reclamation System Phasing Approach

Table 10-6 Phasing Recommendations

Development Condition	Phase [1]	Improvements	Demands	Additional Items & Recommendations
Existing	1	Existing Pipelines	City Demands	• Continue to connect users along existing pipelines (potential of 684 AF)
Near-Term	2	Phase II Park branches	City Demands	• Phase out County Leased Reclamation Area or increase RBPS capacity with second wet-well • Add 6th RBPS pump to existing wet-well • Effluent Management Planning • Condition Assessment
	3A	Pipelines 1 & 2	Village 5/SUD-B (1st phase of development)	
	3B	Pipeline 10	Village 7, Lincoln Crossing	
Long-Term	4	Pipelines 3, 5, 6, 11, 12 & 13	Village 5/SUD-B (2nd phase of development)	• The RBPS expansion should be completed with one of the long-term phases depending on demand conditions • Phase out or limit the PHD of the Machado Farm.
	5A	Pipelines 8 & 9	Loop City System	
	5B	Pipelines 4 & 7	Loop City System	
		RBPS Expansion	PHD – Long-Term	
Buildout	6	14, 15	V4/SUD-A (1st phase of development)	• Connect V-6 to Machado Pipeline • Add additional pumps to RBPS to meeting PHD as they are added.
	7	16, 18	V4/SUD-A (2nd phase of development)	
	8	17	SUD-A/ Expand system	

1. Phases are numbered in the order in which they are anticipated occur; lettering indicates that the project could be done in either order depending on actual development conditions

To support long-term development conditions, three improvement phases have been recommended. The first phase of these improvements, (Reclamation Phase 4) will include the construction of the remaining pipelines needed to provide service to Village 5/SUD-B and will extend a new transmission main along Nelson Lane north to Nicolaus Road. After the construction of this pipeline, the two main system branches providing service to the City can be looped, providing additional reliability for users. Looping the existing system can be accomplished by implementing either Phase 5A or 5B, although the City may elect to implement both projects at the same time. In addition to these pipeline improvements, it is recommended that an additional reclamation pump station or wet well is added to support PHDs of long-term development. Improvements to the RBPS should be included as a part of one of the proposed phases.

The remaining three phases of improvements support full buildout development, providing service to Village 4, SUD-A, and Village 6. Phase 6 includes construction of pipelines 14 and 15 to supply the initial development of Village 4 and SUD-A. The existing Machado Pipeline can be used to supply Village 6; the connection of this Village should be made upon development and isn't impacted by prior or subsequent phasing. Phase 7 includes the construction of pipelines 16 and 18 to provide service to further development within Village 4 and SUD-A, the City may wish to divide this into two separate projects depending on actual development within these areas. The final recommended phase includes the construction of Pipeline 17 along Aviation Drive, providing an additional loop to the future system, adding capacity, redundancy and helping the system meet pressure requirements at buildout. This pipeline provides reliability to Village 4 and SUD-A users and could support additional demands within the City's SOI, outside of the recycled water service area. The RBPS will have to be expanded as demands increase, and RBPS improvements should be reconsidered if demands exceed those projected herein.

11.0 COST ESTIMATES

11.1 PURPOSE

The purpose of this chapter is to present opinions of probable cost for the capital improvements projects (CIPs) recommended as part of this Reclamation Master Plan. Planning level opinions of probable costs have been developed for repair and replacement (R&R) of existing pipelines, proposed CIPs needed to supply recycled water to future users under buildout development conditions, and reclamation system operation and maintenance (O&M) costs.

It should be noted that the cost parameters presented herein provide appropriate budgets for the reclamation project elements as standalone projects. If they are implemented as part of a larger development project, whereby environmental services, design, management, inspection and road and traffic impacts and details are spread across other project components, these budgets provide conservative cost estimates.

This chapter is divided into the following sections:

- Cost Basis and Assumptions
- Future Growth CIP Costs
- Reclamation O&M Costs
- On-going R&R Program
- Summary

11.2 COST BASIS AND ASSUMPTIONS

The level of accuracy for cost estimates varies depending on the level of detail to which the project has been defined. Master planning represents the lowest level of accuracy, while pre-bid estimates represent a much higher level of accuracy. The American Association of Cost Engineers (AACE) has developed a cost estimate classification system used to define the anticipated level of accuracy of cost estimates based on project maturity.

The cost estimates presented in this Master Plan should be considered order-of-magnitude estimates and have been prepared as Class 4 estimates in accordance with AACE guidelines. As Class 5 estimates, the accuracy ranges from -30 to +50 percent. These costs have been estimated in December 2019 dollars consistent with the Engineering News Record construction cost index (ENRCCI, 20-Cities Average) of 11,381. Future adjustments of cost estimates can be projected by increasing the estimated capital cost by the ratio of the future ENR to 11,381.

11.2.1 Capital Costs

Cost estimates for each system expansion segment is a combination of construction costs and project costs. Construction costs account for the budget required for a contractor to install the proposed infrastructure. Project costs account for project contingencies, administration, engineering, planning, and environmental documentation. Capital cost estimates include the base construction costs, a 35 percent estimating contingency, and a 25 percent allowance for engineering, environmental services, and administration.

The pipeline costs estimates represent those associated with primary transmission mains in the future distribution system. The cost of pipelines less than 8-inches in diameter (distribution mains) are not included. The unit costs for transmission pipelines is based on $18/diameter-inch/linear-foot of pipe, including all construction cost elements. Pump station improvement costs were developed by scaling the pre-bid estimate and actual construction costs of the existing RBPS and improvements thereto.

11.2.2 O&M Costs

O&M costs consider purchased power for pumping, labor for WWTRF staff to operate and maintain the reclamation system and assist City staff at use areas, and ongoing material costs. The average pumping capacity was used to estimate power consumption. The existing average pumping capacity was determined to be approximately 25% of peak pumping capacity and it was assumed to increase to 33% under buildout conditions. The costs for electricity are based on a unit price of $0.10 per kilowatt-hour (kWh).

Labor costs were approximated based on discussions with WWTRF staff concluding that approximately 4-hours per day is spent operating and maintaining the reclamation system. This amount of time was assumed to increase by 50% under buildout conditions. An hourly rate of $120 was assumed for WWTRF operating staff.

Ongoing material costs include those for chemicals and general equipment parts replacement.

11.2.3 R&R Program Costs

The R&R cost estimates equate to the amount of money the City would need to save each year for a complete replacement of the distribution system component over the remaining years of its useful life. It was assumed that new pipelines will have a useful life of approximately 60 years. The existing system pipelines are assumed to have a reduced useful life to reflect their time of installation and account for portions of the system consisting of repurposed wastewater forcemains. An estimated cost of $280,000 was approximated to replace the existing five RBPS pumps. The expected useful life for the existing pumps is approximately 10-years.

The annual R&R budget presented for each distribution system component represents the amount of money the City would need to save each year of its remaining useful life to replace it assuming 3-percent interest and 3-percent inflation. The total reclamation system R&R budget equates to the sum of the annual costs presented for each installed component of the system. The cost estimate assumes that total annual R&R budget will be inflated each year to represent the current ENR and increased to include replacement allowances for any reclamation system improvements constructed in that year.

11.2.4 Additional Cost Considerations

The cost estimates presented herein do not include customer connection costs, which may include retrofitting the intended use area for Title 22 compliance, tapping the distribution mains, and installing service laterals, meters, pressure reducing valves, and backflow prevention devices. It is assumed that these costs will be the responsibility of the recycled water user. Costs associated with right-of-way land acquisition and construction of distribution pipes less than 8-inches in diameter are not included in the costs presented in this Master Plan.

11.3 FUTURE GROWTH CIP COSTS

Opinions of probable costs associated the CIPs recommended to support future growth and phased expansion of the reclamation system have been established as part of this Master Plan.

11.3.1 RBPS Improvements

Improvements to the RBPS were scaled from previous design estimates and actual improvement costs. The actual RBPS project costs used to develop this estimate were indexed to the current ENRCCI and scaled proportionally to the projected total dynamic head (TDH) and pumping capacity requirements of the RBPS at buildout. This estimate assumes that the City will replace the existing RBPS pumps with higher head pumps over time. Based on the demands identified in this master plan and the reclamation system model, a TDH of 225 feet and a reliable capacity of 19.8 MGD will be necessary to supply the needs of the buildout system. The probable cost of the pump station improvements was approximated as $11,000,000.

11.3.2 New Pipelines

As discussed in preceding chapters, new transmission pipelines are needed to provide service to the City's recycled water service area. Eighteen new pipelines have been proposed, the opinion of probable cost for each is presented in **Table 11-1**.

Table 11-1 Opinion of Probable Cost, New Pipelines

Pipe ID	Description	Pipe Length (ft)	Pipe Size (in)	Construction Cost	Estimating Contingency (35%)	Engineering and Environmental (25%)	Total Project Cost (rounded)
1	Pipeline 1	7,000	30	$3,780,000	$1,323,000	$1,276,000	$6,379,000
2	Pipeline 2	1,000	27	$486,000	$170,000	$164,000	$820,000
3	Pipeline 3	7,000	16	$2,016,000	$706,000	$681,000	$3,403,000
4	Pipeline 4	3,000	14	$756,000	$265,000	$255,000	$1,276,000
5	Pipeline 5	3,000	24	$1,296,000	$454,000	$438,000	$2,188,000
6	Pipeline 6	5,000	18	$1,620,000	$567,000	$547,000	$2,734,000
7	Pipeline 7	6,000	12	$1,296,000	$454,000	$438,000	$2,188,000
8	Pipeline 8	8,000	8	$1,152,000	$403,000	$389,000	$1,944,000
9	Pipeline 9	2,000	8	$288,000	$101,000	$97,000	$486,000
10	Pipeline 10	5,000	12	$1,080,000	$378,000	$365,000	$1,823,000
11	Pipeline 11	3,000	12	$648,000	$227,000	$219,000	$1,094,000
12	Pipeline 12	3,000	8	$432,000	$151,000	$146,000	$729,000
13	Pipeline 13	2,000	8	$288,000	$101,000	$97,000	$486,000
14	Pipeline 14	4,000	16	$1,152,000	$403,000	$389,000	$1,944,000
15	Pipeline 15	1,000	14	$252,000	$88,000	$85,000	$425,000
16	Pipeline 16	5,000	12	$1,080,000	$378,000	$365,000	$1,823,000
17	Pipeline 17	10,000	8	$1,440,000	$504,000	$486,000	$2,430,000
18	Pipeline 18	11,000	8	$1,584,000	$554,000	$535,000	$2,673,000
						Total:	**$34,800,000**

In addition to these improvements, the reclamation system improvement budget should include allowances for the recommendations provided in **Chapter 10.0** for each level of development.

11.3.3 Total Capital Cost Summary

A summary of the total capital cost for the proposed future reclamation system including the pump station improvements and future pipelines is presented as **Table 11-2**.

Table 11-2 Total Cost for New Infrastructure

Item	Description	Cost
1	Future Pipelines	$34,800,000
2	Pump Station Improvements	$11,000,000
	Total:	**$45,800,000**

A summary of the project costs associated with each recommended improvement phase is presented as **Table 11-3**. The table also includes the total capital cost per AF served annually ($/AF) at buildout for each pipeline. These pipelines will supply more than the projected annual buildout supply over their expected useful life. Therefore $/AF ratio does not represent the actual value of each AF of reclaimed water supplied by each pipeline over its expected lifetime but does provide a relative comparison of the cost to supply the demands associated with each pipeline and the value of each improvement with respect to the buildout system.

The annual volume of reclaimed water supplied at buildout for each pipeline was determined from projected flow through each pipeline within the hydraulic model. The $/AF associated with each phase of development increases as the distribution system is extended further from the RBPS. Pipelines recommended with phases 5A, 5B, 7, and 8 will create loops within the distribution system, which provides additional value to system redundancy and reliability not represented by the $/AF ratio.

Table 11-3 Phased Improvement Costs

Development Condition	Phase	Improvements	Capital Cost Estimate	$/AF Supplied (1)
Existing	1	Existing Pipelines	-	-
Near-Term	2	Phase II Park Branches	$900,000	$14,800
	3A	Pipelines 1 & 2	$7,200,000	$4,200
	3B	Pipeline 10	$1,800,000	$5,400
		Subtotal Near-Term:	**$9,900,000**	**$4,700**
Long-Term	4	Pipelines 3, 5, 6, 11, 12 & 13	$10,600,000	$12,700
	5A	Pipelines 8 & 9	$2,400,000	$17,800
	5B	Pipelines 4 & 7	$3,500,000	$7,700
		RBPS Expansion (2)	$11,000,000	$3,500
		Subtotal Long-Term:	**$27,500,000**	**$11,600 (3)**
Buildout	6	14, 15	$2,300,000	$5,600
	7	16, 18	$4,500,000	$21,700
	8	17	$2,400,000	$71,200
		Subtotal Buildout:	**$9,200,000**	**$14,200 (4)**
		Total:	**$46,600,000**	**$14,700**

1. $/AF supplied represents the total project cost divided by the approximate volume of recycled water supplied through the pipelines annually, under buildout conditions.
2. Pump Station costs may be spread over multiple improvement projects to Long-Term buildout.
3. $/AF excludes RBPS expansion costs, representing pipeline improvements only.
4. The additional value of system reliability and redundancy provided by looping the distribution system is not represented in the $/AF of improvements associated with buildout phases.

11.4 RECLAMATION O&M COSTS

The O&M costs associated with the reclamation system were prepared to consider the on-going costs associated with operating the reclamation system. These costs represent those associated with the WWTRF. Additional costs associated with management of city parks and other use areas are not reflected in these O&M cost estimates.

O&M costs have been approximated for existing and future buildout development conditions using 2019 dollars. It is expected that additional O&M costs will be incurred as each phase of the distribution system expansion is implemented. O&M cost estimates under existing conditions are presented in **Table 11-4** and O&M cost estimates under buildout conditions are presented in **Table 11-5**.

Table 11-4 Existing Reclamation System O&M Costs

Item	Description	Quantity	Units	Unit Price	Total Cost
1	Power (RBPS)	610,974	kWh/ year	$0.10	$61,000
2	Labor (WWTRF Staff)	1,460	hours/ year	$130.00	$190,000
3	Chlorine	8	Tote of Chlorine	$600	$5,000
4	Maintenance and Replacement Parts				$2,500
				Total:	**$256,000**

Table 11-5 Future Reclamation System O&M Costs

Item	Description	Quantity	Units	Unit Price	Total Cost
1	Power (RBPS)	2,150,628	kWh/ year	$0.10	$215,000
2	Labor (WWTRF Staff)	2,190	hours/ year	$130.00	$285,000
3	Chlorine	32	Tote of Chlorine	$600	$19,000
4	Maintenance and Replacement Parts				$5,000
				Total:	**$524,000**

11.5 ON-GOING R&R PROGRAM

No hydraulic deficiencies were identified within the existing distribution system and as a result no CIPs are recommended for the existing system as part of this Master Plan. Although no improvements to the existing system are recommended, funding will be needed to support the City's on-going repair and replacement (R&R) program. A robust R&R program is a key element of any properly managed public infrastructure system and includes an annual expenditure for the replacement of older, aging infrastructure. The annual R&R allocation is intended to reduce the impact of repairing and replacing critical portions of the City's reclamation system by stretching them out over time.

The cost estimates to replace the existing reclaimed water distribution pipelines are presented in **Table 11-6**. The replacement costs for existing pipelines in the reclamation system have been estimated to be incorporated into an on-going R&R program.

Table 11-6 Existing Reclaimed Pipeline Replacement Costs

Item	Description	Pipe Length (ft)	Pipe Size (in)	Construction Cost	Estimating Contingency (35%)	Engineering and Environmental (25%)	Total Project Cost (rounded)
1	Fiddyment Road	8,000	24	$3,456,000	$1,210,000	$1,167,000	$5,833,000
2	Foskett Park	2,000	8	$288,000	$101,000	$97,000	$486,000
3	Joiner Parkway	15,000	12	$3,240,000	$1,134,000	$1,094,000	$5,468,000
4	Machado - Part 1	7,000	14	$1,764,000	$617,000	$595,000	$2,976,000
5	Machado - Part 2	6,000	16	$1,728,000	$605,000	$583,000	$2,916,000
6	Moore Road	18,000	18	$5,832,000	$2,041,000	$1,968,000	$9,841,000
7	Sorrento	3,000	8	$432,000	$151,000	$146,000	$729,000
8	SPI Supply Line	1,000	8	$144,000	$50,000	$49,000	$243,000
9	At WWTRF	100	30	$54,000	$19,000	$18,000	$91,000
						Total:	**$28,600,000**

The total annual R&R budget equates to the sum of the annual R&R presented for installed components. The current annual R&R budget equates to approximately $675,000. This value should be indexed annually using the ENRCCI, 20-Cities Average. Future adjustments of cost estimates should be estimated by increasing the annual replacement budget or capital cost estimate by the ratio of the future ENRCCI, 20-Cities Average to 11,381 (December 2019). After completing the Phase II reclamation project, the R&R budget will increase to $690,000 and inflated by the ENR ratio at the time of project completion.

Table 11-7 On-going R&R Costs Budget

Development Condition	Phase	Improvements	Capital Cost Estimate	Remaining Years Useful Life	Annual Replacement Budget Starting at Time of Construction
Existing	1	Existing Pipelines	$28,200,000	45	$646,000
	1	Existing Pumps	$280,000	10	$29,000
		Subtotal Existing:	**$28,480,000**		
Near-Term	2	Phase II Park branches	$900,000	60	$15,000
	3A	Pipelines 1 & 2	$7,200,000	60	$124,000
	3B	Pipeline 10	$1,800,000	60	$31,000
		Subtotal Near-Term:	**$9,900,000**		
Long-Term	4	Pipelines 3, 5, 6, 11, 12 & 13	$10,600,000	60	$182,000
	5A	Pipelines 8 & 9	$2,400,000	60	$41,000
	5B	Pipelines 4 & 7	$3,500,000	60	$60,000
		RBPS Expansion (2)	$11,000,000	30	$378,000
		Subtotal Long-Term:	**$27,500,000**		
Buildout	6	14, 15	$2,300,000	60	$39,000
	7	16, 18	$4,500,000	60	$77,000
	8	17	$2,400,000	60	$41,000
		Subtotal Buildout:	**$9,200,000**		
		Total Capital Costs:	**$75,080,000**		

1. To be cumulatively added to annual reclamation R&R budget at time of construction.
2. Index costs with CCI annually to bring values to present worth at time of construction.

11.6 SUMMARY

The existing system R&R costs, capital improvement costs, and O&M cost estimates developed as part of this Master Plan are summarized in **Table 11-8**.

Table 11-8 Summary of Cost Estimates

Cost Estimate Type	Improvements	Cost Estimate	Recommendations
Existing System R&R	Existing Pipelines	$28,200,000	• Continue to connect users along existing pipelines. • Monitor pump station performance add sixth pump to existing RBPS to meet demands and pressure requirements.
	Existing Pumps	$280,000	
	Subtotal Existing System R&R:	**$28,480,000**	
Capital Impartments Project Cost	Near-Term	$9,900,000	• Phase out of County Leased Reclamation Area and/or increase RBPS capacity to meet demands. • Effluent Management Planning • Perform condition assessment on existing infrastructure. • Continue discussion with Placer County regarding their portion of effluent, per COJA.
	Long-Term	$27,500,000	• RBPS expansion project should occur with one of the long-term phases depending on demand conditions, pumps can be added as demand increases. • Phase out or limit the PHD of the Machado Farm.
	Buildout	$9,200,000	• Add pumps to the RBPS to meet PHD as they increase. • Utilize the existing Machado Pipeline to serve Village 6.
	Subtotal CIP Costs:	**$46,600,000**	•
O&M Costs (WWTRF)	Existing System	$256,000	•
	Buildout System	$524,000	•

APPENDICIES

Appendix A RULES AND REGULATIONS FOR RECYCLED WATER USE AND DISTRIBUTION

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Appendix B DEMAND DETAILS